Compressed Air Magazine

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DIPPING WIRE WITH AIR-OPERATED HOIST (See Page 5336)

ON THE COVER

THIS picture illustrates an operation in the plant of The Riverside Metal Company, which is described in this issue. It shows alloy wire about to be lowered by an air-operated hoist into a tank containing trichlorethylene. This is done to remove grease from the wire prior to annealing it in the adjacent nonoxidizing electric furnace.

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IN THIS ISSUE

EXCEPTING iron, copper is probably mankind's most serviceable metal. In its pure state it has many important uses, and in combination with other metals it has many more. Copper can be readily alloyed, producing a long list of brasses, bronzes, and other materials that give the arts and industries a wide choice. The preparation of these alloys is an exact science that calls for painstaking care in processing and vigilant metallurgical control. Our leading article tells something of the methods employed by one specialist in this line.

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IT IS difficult to realize that the noonday whistle did not always blow, that alarm clocks were not numbered among medieval instruments of torture, and that watches came within the reach of all as recently as the past century. Yet, for many hundreds of years time was measured by the sun's shadow. Small wonder then that the sundial was developed to a high degree of accuracy. Some interesting facts regarding these timetellers of the ages are presented this month.

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IN THE western part of the United States numerous highways follow the grades of railroads that lost their usefulness because the mining camps they served turned into ghost towns when their ore petered out. Now Pennsylvania comes forward with a scheme similarly to employ the route of a railway that died aborning. Thus a $10,000,000 project of the 1880's may become a $50,000,000 project of the 1940's.

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THE Iroquois Indians were a strong confederacy. Through their five nations they successfully held control against their own race of some of the best part of what is now the United States. Especially coveted by white men was the valley through the Appalachians where the Mohawks lived and stood guard. Eventually they drove the redman out and transformed the valley into a bustling avenue of commerce and industry. Those that are rusty on this chapter of American history may refresh their memories by reading *In the Valley of the Mohawks*.

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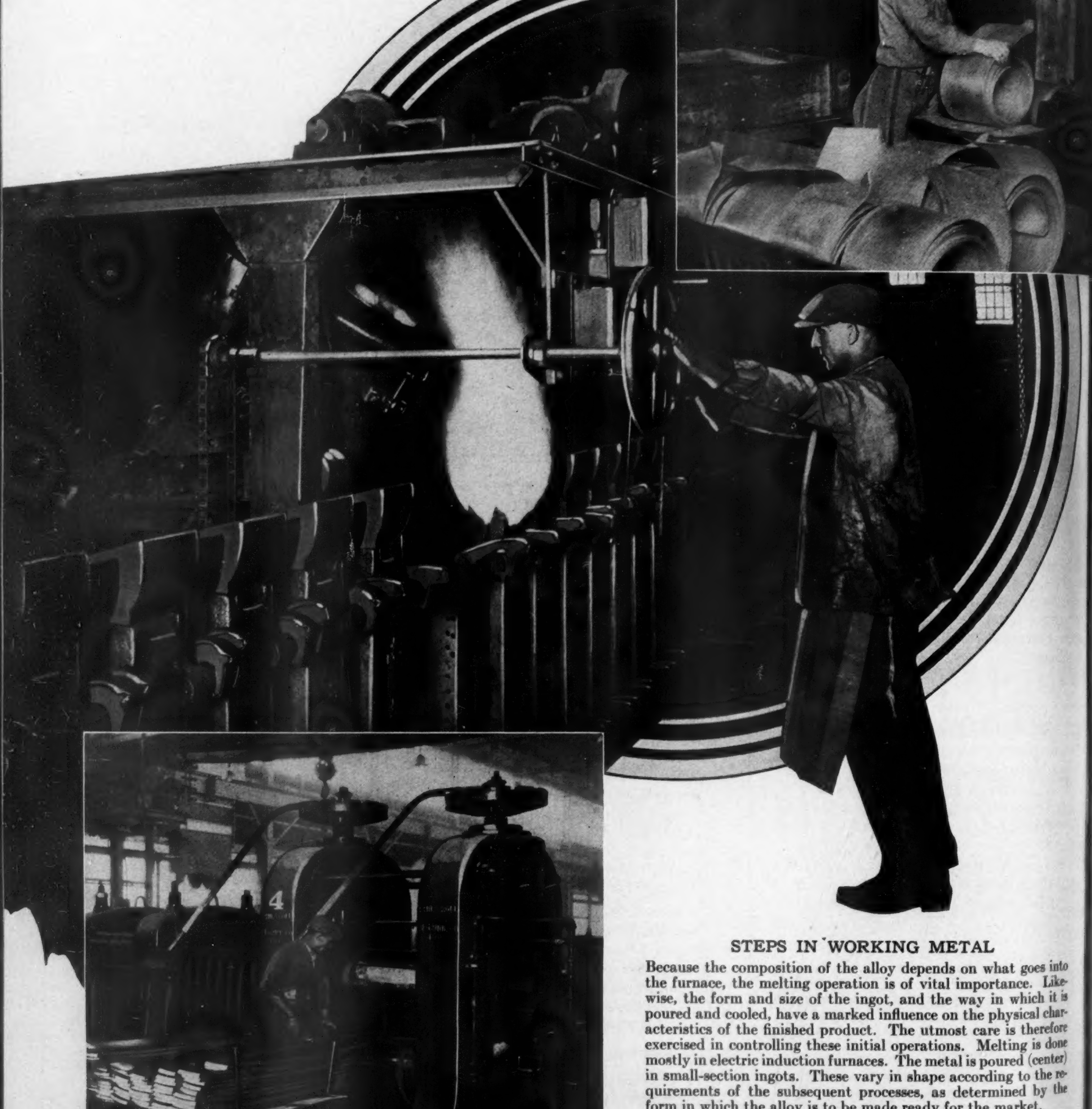
Copper Alloys for Many Purposes

C. H. Vivian



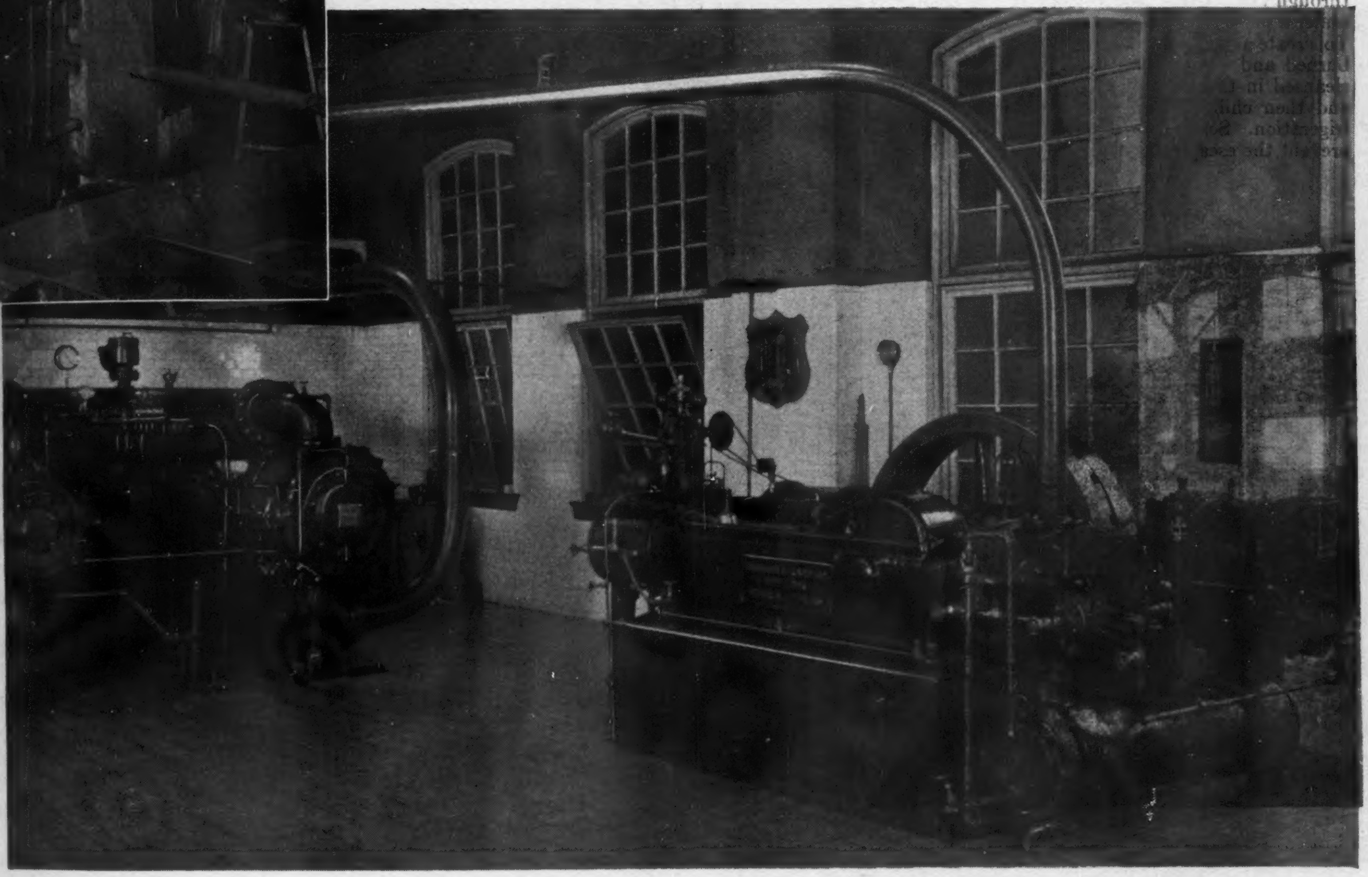
STEPS IN WORKING METAL

Because the composition of the alloy depends on what goes into the furnace, the melting operation is of vital importance. Likewise, the form and size of the ingot, and the way in which it is poured and cooled, have a marked influence on the physical characteristics of the finished product. The utmost care is therefore exercised in controlling these initial operations. Melting is done mostly in electric induction furnaces. The metal is poured (center) in small-section ingots. These vary in shape according to the requirements of the subsequent processes, as determined by the form in which the alloy is to be made ready for the market.

Initial reduction of ingots intended for flat products is accomplished in a break-down mill. This department was enlarged and modernized in 1930, with a consequent increase in capacity of around 20 per cent. The roll shown at the left reduces heavy bars from a thickness of 2 inches to 0.30 inch. Further reduction is effected by repeated cold-rolling. One of the finishing rolls is seen at the top. Rolling must be closely regulated to assure a smooth surface, correct temper, accurate gauge, and true flatness.

COMPRESSED-AIR SUPPLY

Compressed air is used principally for operating the hoists that are used in handling the metal, but it also performs numerous other services. The air is furnished at 100 pounds pressure by the two compressors shown below. Normal plant requirements are supplied by the electric-driven unit at the left, while the older steam-driven machine at the right is for supplemental and standby service. To insure dry air, the discharge from both compressors passes through an aftercooler before going into the distribution system.



THIS has appropriately been called the age of alloys, and it may well go down in industrial history as such. Certain it is that special metallic materials are of great importance and that their use is being continually extended. A few alloys were known to the ancients; but only during the past 30 years or so has serious attention been given to combining two or more metals to obtain a product with more desirable characteristics than any one of them, alone, possesses. Progress in that brief period has been extremely rapid. Steel, which is itself an alloy of iron and carbon, is no longer the specific term it once was, for we now have a multitude of steels, each having what might be called its own personality that gives it advantageous properties for certain uses. The same is true in the nonferrous metal field.

Brass and bronze have been known for centuries, but neither designation is now distinctive for there are scores of brasses and bronzes, each having a definite composition and definite characteristics. Today, alloys are made after exact formulas, much as a pharmacist compounds medicines according to the prescription of a physician. In the metal world, the metallurgist is both doctor and pharmacist. His patients are the various industries. He diagnoses their problems and prescribes curative metallic mixtures. His mortar and pestle are an electric furnace, reminiscent of the boiling cauldron in which the witches of old brewed their evil potions.

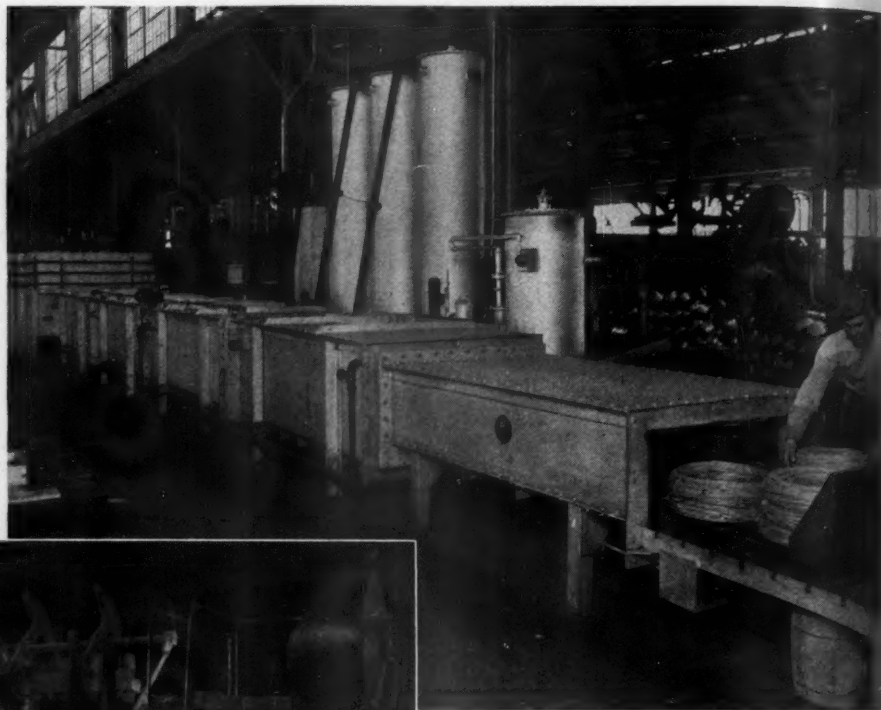
The production of alloys is largely a specialty business, and it is growing more so year by year. There are numerous companies whose entire plant is devoted to the making of a single steel alloy, and in the nonferrous field sizable firms have been built up on the production of the alloys of an individual metal. Where such a concentration of effort exists, there is full opportunity to develop a highly effective manufacturing technique and to exercise such close control that the products are held within narrow limits of variation.

To illustrate this point, we may cite the case of The Riverside Metal Company of Riverside, N. J. That concern confines its business largely to the making of phosphor bronze, nickel silver, and beryllium copper. Yet it produces fourteen separate and distinct alloys under the first heading and 28 under the second, and guarantees that in none of them will there be a variation of more than 1 per cent in the specified proportions of any of the component metals. This means that in what is known as 5 per cent nickel silver, in which the nickel content is theoretically 5 per cent of the total mass, a customer can be sure that it will be within five ten-thousandths of that amount. Even gourmets would hardly expect a chef to be so meticulous in proportioning the ingredients for the foodstuffs he prepared for them, and yet such close control is considered of vital importance in turning out good alloys.

If there had been a dependable supply of high-grade alloys for watchcases 40 years ago, The Riverside Metal Company might not be in existence today. The Key-

ANNEALING FURNACES

All reduction from ingots to finished products is effected by working the alloy metals in their cold state. Because this hardens them, they must be annealed from time to time to again soften them for further reduction. The picture below shows partially finished products in front of a conventional annealing furnace. A recent addition to the plant is the electric annealing furnace pictured at the right. This apparatus provides an atmosphere of inert gas which prevents oxidation of the metals as they are pushed through the furnace by a plunger driven by oil under a pressure of 600 pounds per square inch. To create this atmosphere, illuminating gas is burned and the product passed through coils, cleansed in the three scrubbing towers shown, and then chilled by means of mechanical refrigeration. Seals at either end of the furnace prevent the escape of the gas.



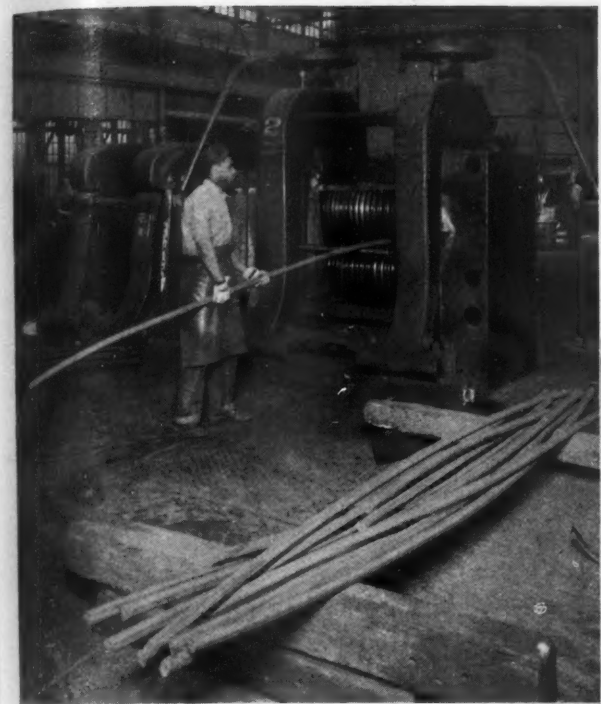
stone Watch Case Company, then and now the largest firm of its kind, had difficulty in obtaining suitable metals for the manufacture of cases for Howard watches and for other makes. To fill this need, a separate business was established in 1897. For a number of years its products went chiefly into watches. But when it became apparent that various other industries required high-grade alloys such as it was turning out, the company began to supply the general trade. Phosphor bronze and nickel silver have remained its major products, beryllium copper having been added only four years ago. The output now ranges around 18,000,000 pounds a year.

Excepting beryllium copper, these alloys are rather well known; but some facts concerning them may be of interest. Bronze was, of course, the principal metal employed by certain pre-Christian nations for making household utensils, weapons, and objects of art. Its resistance to corrosion is attested to by the splendid condition of many such articles excavated after centuries of burial. Ordinary bronze is an alloy of copper and tin. In 1854 it was discovered, in France, that the addition of a little phosphorus, which served as a deoxidizer, made it possible to produce sounder castings of improved physical properties and of markedly higher resistance to corrosion. The presence of phosphorus, however, greatly increased the difficulties of making and fabricating the alloy. Accordingly, the production of phosphor bronze became a somewhat specialized field, calling for an intimate knowledge of the characteristics of the alloy and careful control of all steps in its manufacture.

Phosphor bronze has many applications, being suitable for use wherever there is need for a metal of toughness, high elasticity, and good resistance to corrosion, abrasion, and fatigue. It is employed in various types of machinery, in electrical and radio appliances, and in bridges, where it serves as expansion and bearing plates. Some rock drills contain as many as three important phosphor-bronze parts.

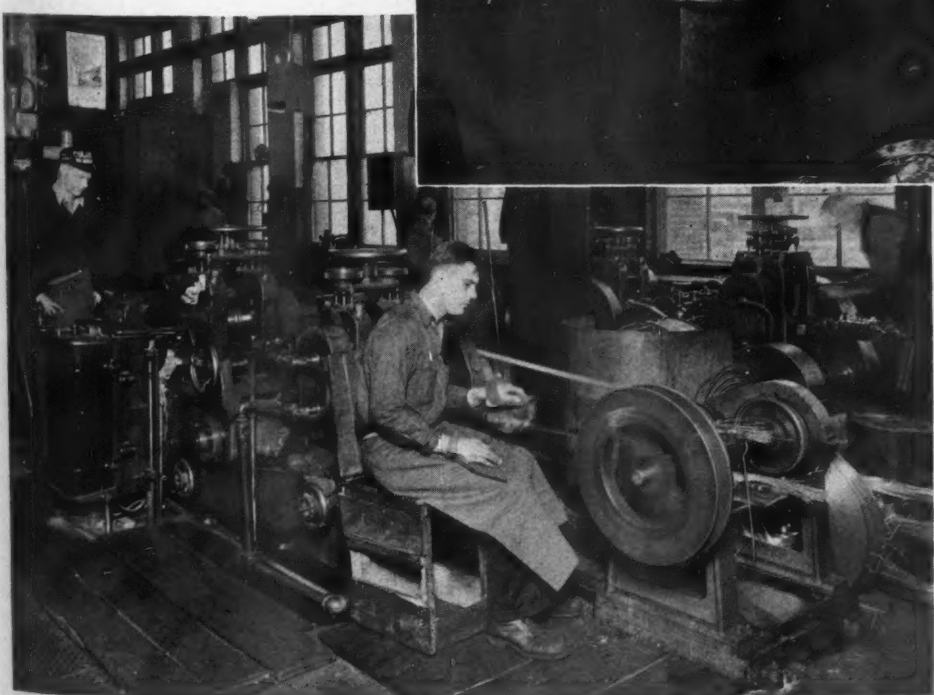
Nickel silver was first made in China under the name of *packfong*, meaning white copper. In the seventeenth century it was introduced into Europe, where the guild of metalworkers improved the existing smelting and refining processes. It was still a rather crude alloy, however, when, in 1823, the Society for Promoting Industry in Prussia offered a prize for an alloy that would have the appearance of silver but would cost only one-sixth as much. Almost simultaneously, in the following year, Henniger Brothers of Berlin and Doctor Geitner of Schneeberg came forward with virtually the same alloy, which they had prepared after analyzing *packfong*. Being German, the prize winners called the metal *Deutsches Silber*, or German Silver. Its current name differs in various countries, nickel silver being its usual designation in the United States and England. It is composed of copper, nickel, and zinc, in proportions that vary according to its intended service. Copper constitutes from 55 to 75 per cent of it, nickel from 5 to 30 per cent, and zinc the remainder.

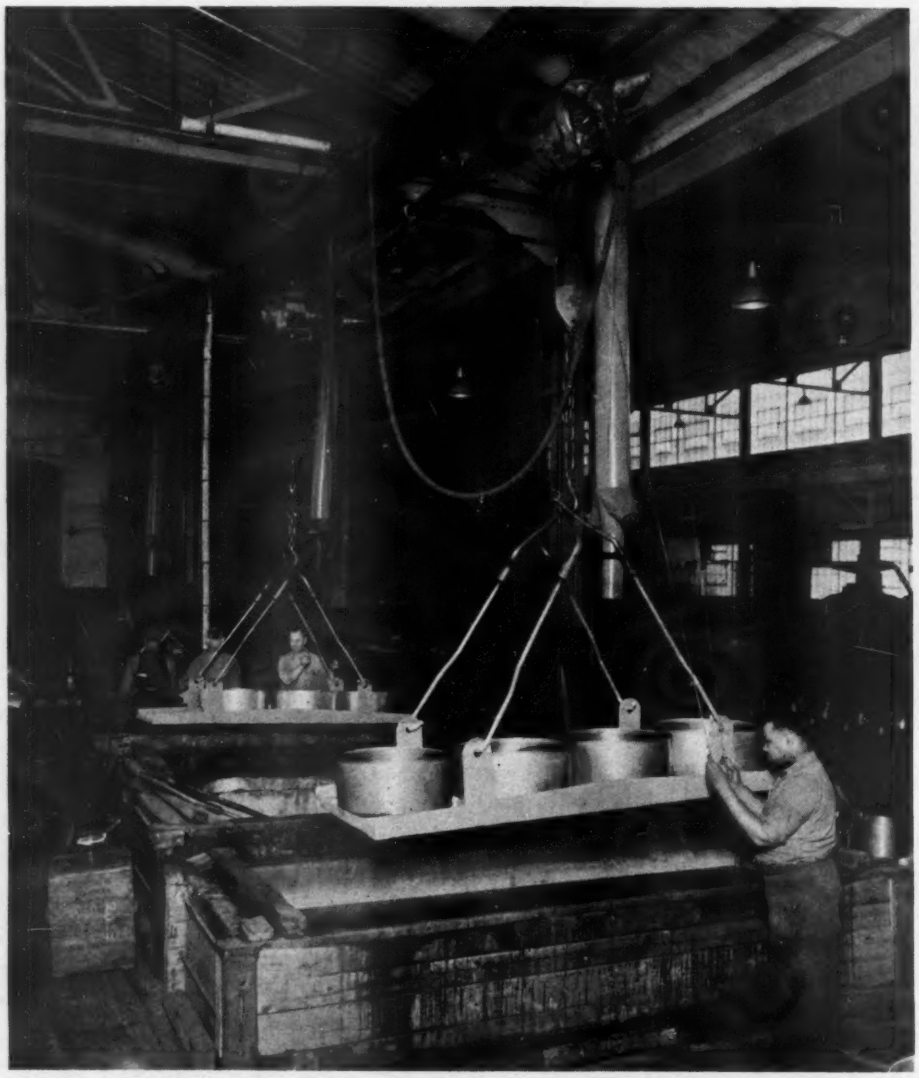
Nickel silver has an extremely diversified field of application. Being silvery white clear through, there is no surface to rub off. It will take a high polish, or it can be given a satinlike finish that does not show finger marks. It is tough, resists corrosion and mechanical wear well, and can be readily stamped, drawn, or spun. It lends itself well to plating, and as the base harmonizes with the superimposed metal, it presents no unpleasant contrast when some of it is exposed through wear. The most familiar use of nickel silver is as a base metal for plated silverware, both hollow and flat. It is also widely utilized in the manufacture of architectural hardware, dairy and hospital equipment, musical instruments, soda-fountain and restaurant equipment, optical goods, surgical appliances, for jewelry, automobile and marine trim, keys, and for countless other articles. One of its



WIRE-MAKING OPERATIONS

Bars are first reduced in break-down rolls (left). Each resultant rod is next reduced to a diameter of around 0.25 inch by passing it through a series of bull blocks, one of which is seen immediately below. The rod is wrapped around the revolving drum at the right and thence pulled through a die. This leaves it in the form of a loop, which facilitates its handling for annealing and subsequent drawing. Round wire is made from a rod by drawing the latter through a succession of dies, as shown in the second picture below. For drawing small wire, a series of dies is immersed in a coolant. Flat wire is produced by rolling round wire, as illustrated at the bottom.





PICKLING

After each annealing, the metal is cleansed of adhering scale by immersing it in tanks containing acid solutions. The treatment depends upon the resistance of the various alloys to different acids. In all cases, it is necessary to take great care, lest the body of the metal be attacked and its surface pitted. The trays of material are dipped by means of air-operated hoists suspended from monorails overhead. Such hoists assure quick action, ease of control, and ample power, and they cannot be damaged by overloading. There are 24 of them in the plant, and they range in capacity from 1,000 to 2,000 pounds each. An automatic brake holds the load in case the air supply fails, and automatic stops prevent overruns of the cable, both up and down.

more recent applications is in the making of slide fasteners, or zippers.

Beryllium copper is one of the newest wonder metals. Metallurgists term it not only interesting but arresting. Its most striking characteristic is its "hardenability." When properly heat treated, it attains a degree of hardness approaching that of steel. It has been suggested that this might explain the reputed ability of some ancient peoples to temper copper. It is thought probable that some of their copper contained a little beryllium or similar element, but that its presence was more a matter of accident than of design.

Although metallic beryllium was produced in the laboratory in 1828, no useful application for it was known so recently as 1923, and its production in commercial quantities began only five or six years ago. It is as widely disseminated through the earth's crust as is tin; but its distribution is so sparse and the difficulties of extracting it were, until lately, so great as to constitute real obstacles to its exploitation. In 1924 beryllium sold for $5,000 a pound. Its price during recent months has ranged from $30 a pound upward. It is predicted that further reductions will be made as extraction processes are improved and the demand for beryllium increases.

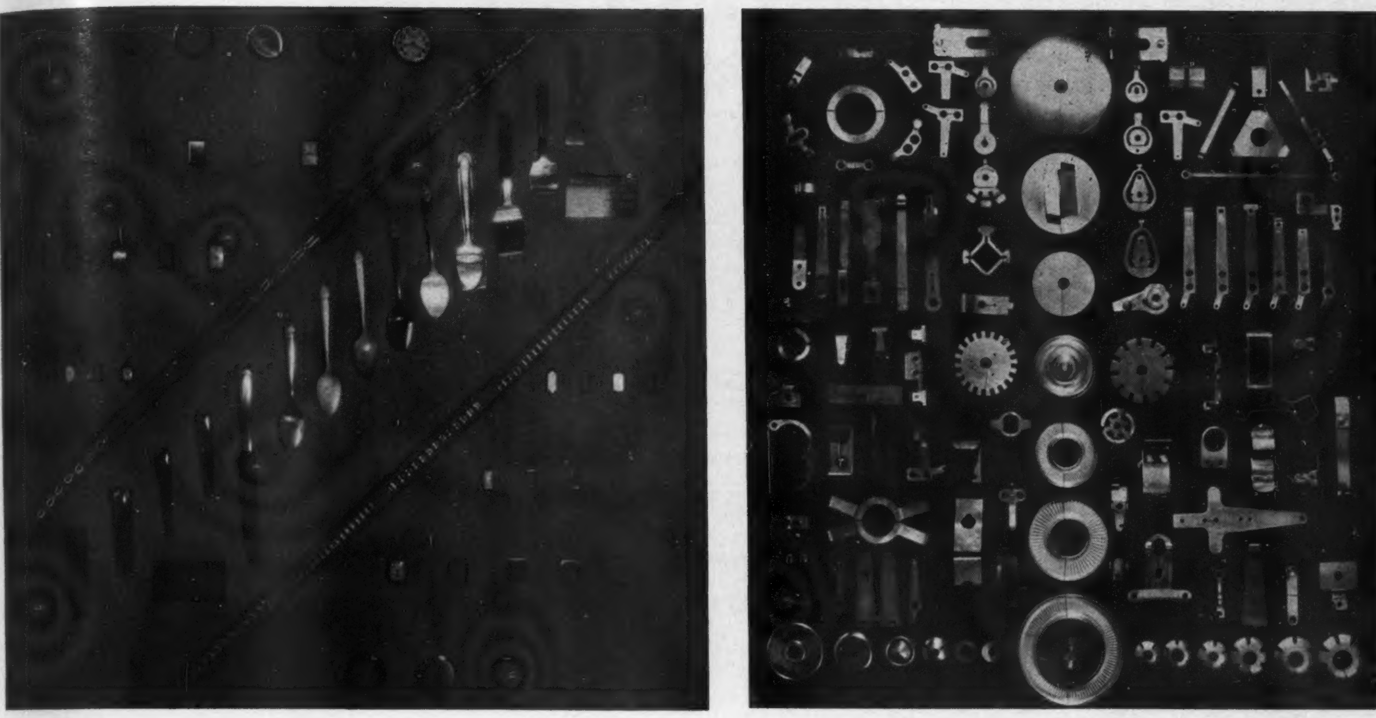
The chief source of beryllium is beryl, a complicated beryllium-aluminum silicate which exists in its purest form in the gem emerald. Beryl contains only from 4 to 5 per cent of beryllium. A large beryllium-bearing deposit is in the Black Hills of South Dakota. Because of the relative scarcity of the mineral, the United States in 1932 prohibited exportation of beryl.

Metallic beryllium is 30 per cent lighter than aluminum, its specific gravity being 1.84. It is of steel-gray color, takes a high polish, and renders itself virtually immune to corrosion through the formation of a protective surface film of oxide. It melts at 2,336°F; has a strong affinity for oxygen; and is used as a deoxidizing agency in the refining of copper.

Most commercial alloys of beryllium and copper thus far produced have a beryllium content ranging from 1.50 to 2.50 per cent. The latter figure represents the maximum proportion of beryllium that will permit the alloy to be worked cold and still retain desirable physical characteristics. This is an important consideration where ultimate hardness is desired, as cold reduction prior to heat treatment produces an alloy of considerably greater tensile strength than heat treatment from the soft state. Combined cold rolling and heat treatment of a 2.25 per cent alloy will result in a tensile strength of upwards of 170,000 pounds per square inch. This compares favorably with certain steels. Such beryllium-copper alloys are therefore suitable for making wrenches, screw drivers, chisels, and other nonsparking tools for use in oil refineries, explosives factories, and other places where the employment of steel tools is dangerous.

Other desirable characteristics of this alloy are its high modulus of elasticity, high fatigue resistance, good electrical conductivity, nonmagnetic properties, machinability, and ductility in the annealed state. It can be joined by all the usual methods, including welding, and can be plated with all the finishing metals ordinarily used. Its conductivity, elasticity, and resistance to fatigue stress render it desirable for the making of such electrical parts as contact clips on cord sets and pins in household appliances where commonly used materials fail or lose their effectiveness through arcing and burning of the contacts. For the same reasons it is a superior metal for wall switches, relay parts, circuit-breaker contacts, brush-holder springs, and electrical- and recording-instrument springs. Its resistance to flexure has been strikingly demonstrated many times. Where plate springs of most metals fail at around 400,000 bends, tests have shown that those of beryllium copper will withstand 10,000,000 bends without fracturing. This property opens the way to countless applications of the alloy in industrial machines. Bearings of beryllium copper containing 1 to 2 per cent beryllium are reported to give six times the service of silicon-bronze bearings, and are consequently being used increasingly in locomotives. It is safe to predict that as the price of beryllium decreases its employment in the form of copper alloys will mount perceptibly. The demand for beryllium rose fourfold in 1936, and it is estimated that 90 per cent of it was alloyed with copper.

As previously mentioned, The Riverside Metal Company produces alloys of various compositions. It furnishes phosphor bronze and nickel silver in sheets, strips, bars, rods, wire, circles, and blanks, and beryl-



NICKEL-SILVER AND PHOSPHOR-BRONZE PARTS

Although it has many applications—telephone switchboards, for example—where it is not visible, nickel silver is extensively used for the making of articles calling for a metal that combines serviceability with good appearance. The left-hand picture shows typical watchcase parts, chains, and plated flatware of Riverside nickel silver. Phosphor bronze is more of an industrial metal, and has a wide field of service. The articles at the right are parts for electrical equipment.

lium copper in sheets, strips, rods, and wire. The manufacturing process consists of melting the required proportions of the component metals, pouring the resultant alloys into castings, and then working the latter into the different forms in which the trade desires them.

All these alloys are cold-worked. Castings are turned out in shapes that will facilitate their further processing. The primary reduction is made in break-down rolls, after which the alloy is rolled or drawn to ultimate size, depending upon whether it is to be marketed in flat form, such as sheets or strips, or in round form, such as rods or wire. As it is an inherent characteristic of these alloys to harden when being cold-worked, they must be annealed periodically to restore their original softness. As a result, all products spend a considerable proportion of their processing time in one or another of the eleven annealing furnaces in the plant.

After each annealing the alloys must be cleaned of all adhering scale, lest these be worked into the metal. This is done by immersing them in pickling tanks, containing, respectively, sulphuric acid, chromic acid, and water. The cleansing treatment varies with the metal. In the case of each of the several groups of pickling tanks, the receptacles containing the reagents are arranged in line so that materials can be moved from one to another in the desired sequence. For convenience in handling in getting them in and out of the tanks, they are loaded on noncorrosive-metal trays which are suspended by cables from air-operated hoists traveling on overhead monorails. There are 24 Ingersoll-Rand hoists in this service, ranging in individual capacity from 1,000 to 2,000 pounds.

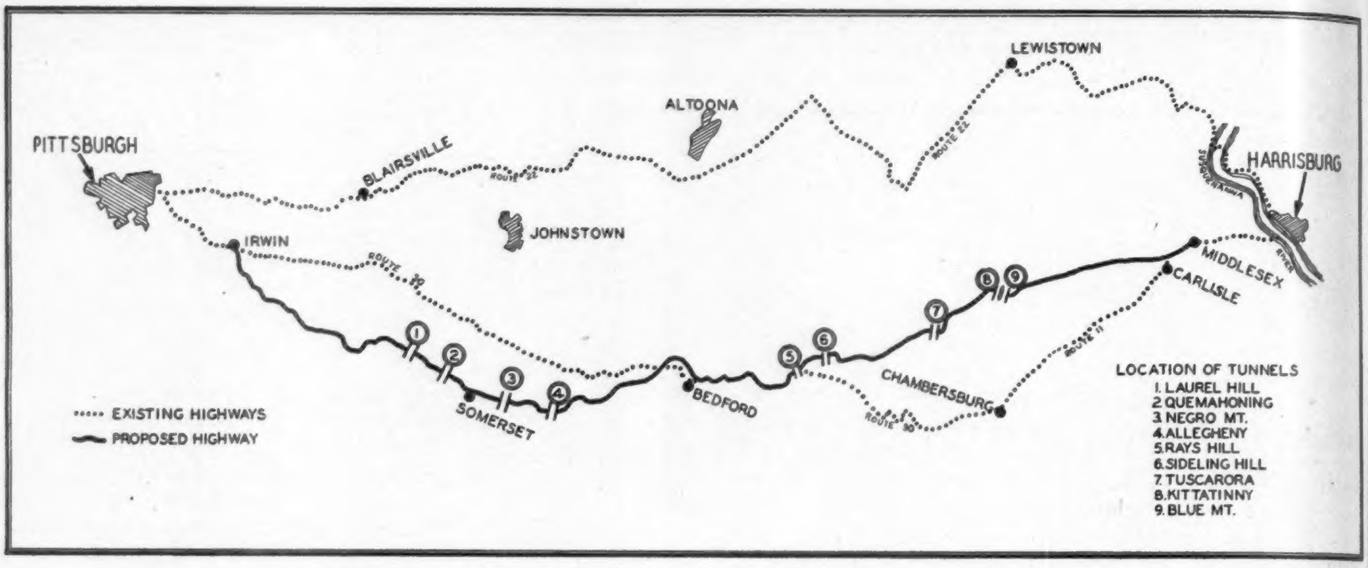
In addition to its use for the purpose just mentioned, compressed air serves in the plant for cooling hot spots on the walls of the melting furnaces, for operating a press that bales scrap metal, and for running chipping and riveting hammers and pavement breakers required in maintenance work. The compressor plant consists of two Ingersoll-Rand machines. A Type XRE direct-connected, synchronous-motor-driven unit of 676 cfm. piston displacement carries the ordinary load while an older steam-driven compressor is used for peak-load and standby services.

At the outset of this article was mentioned the closeness with which the compositions of the various alloys are controlled. Hand in hand with it goes accuracy and care in processing the metals to assure final products not only of the exact dimensions desired but also of the precise hardness and other physical properties that will make them suitable for the individual needs of the concerns that manufacture the various articles in which they ultimately reach the market. These factors, which are the result of painstaking attention to detail, are responsible in large part for the good reputation enjoyed by Riverside metals.

Back of this careful regard for the small but important things are the company's research and laboratory facilities. A capable staff of technicians, provided with modern equipment, sees that nothing is left to chance. Physical, chemical, and photomicrographic tests check the plant operations at all stages. A ladle sample is taken of every melt, and the latter is not released until chemical analysis has confirmed the correctness of its composition.

In many cases the grain structure of the alloy is an important consideration to the customer, and it is therefore controlled within narrow limits and checked by photomicrographs. Specifications for grain-size control have been established, and are based upon individual requirements of fabrication, final finish, and performance. Materials are tested for tensile strength on a Rockwell hardness testing machine, and if there is any doubt after that, an actual tensile test is made. Specifications are written for all alloys sent out. If none has been established, or if a customer does not furnish one, then it is made up by the metallurgical staff.

Much of the work of the chemical and physical laboratory is concerned with checking and recommending suitable materials for the specific and widely varying needs of customers. It is through these practices that the company has become a specialist in its field. In addition to the aforementioned routine activities, the laboratory conducts considerable pure research work to find new applications for alloys now being made and to investigate the possibility of adding new alloys to its list of products. It was through this sort of endeavor that the concern became engaged in the manufacture of beryllium copper.



ROUTES OF EXISTING ROADS AND PROPOSED SUPERHIGHWAY

Superhighway to Follow Old Rail Route

Allen S. Park

AFTER a lapse of more than 50 years, the right of way of a $10,000,000 railroad in Pennsylvania that never ran a train is to be converted into a superhighway connecting Harrisburg and Pittsburgh. It will be a 4-lane, divided roadway having few curves and no steep grades. Instead of crossing the mountains, as existing highways do, it will tunnel through them. As a consequence, it will be affected relatively little by fog, ice, and other adverse meteorological conditions, and will be a truly "all-weather" route.

This new road, which will cost between $50,000,000 and $65,000,000, has been authorized in a bill passed by the Pennsylvania State Legislature and signed by Gov. George H. Earle. The act creates a construction and administrative agency to be known as the Pennsylvania Turnpike Commission. The building of the highway will be financed by issuing bonds. It has been estimated that a yearly revenue of $5,000,000 can be obtained from tolls to be charged for the use of the nine tunnels included in the route, a sum sufficient to meet interest payments on the bonds, to maintain the highway, and to amortize the indebtedness in less than 40 years. It is therefore expected that no state funds will be required and that no burden will fall on the taxpayers. The act provides that the road, after it is paid for, shall become a part of the state highway system and shall be open to the free use of the public. During the period of toll operation, upkeep and repairs will be taken care of by the State Department of Highways but will be paid for by the commission.

The route will follow the line of the abandoned South Penn Railroad grade, an ambitious project of the "eighties" that was stopped as suddenly as it was started. Essentially, it was a pawn in the game of chess that was played by the railroad barons of that day. Just 100 years ago, surveyors, who had been commissioned to locate a right of way for a railroad between the Cumberland Valley at Chambersburg and the Ohio Valley at Pittsburgh, determined that the most direct course lay through the southern tier of the Pennsylvania Alleghenies. Construction was begun, but after $300,000 had been spent on the undertaking it was abandoned because it was deemed too expensive. Subsequently the scheme was periodically revived, but the financial obstacles were, in the end, always considered insurmountable.

But in 1883, William H. Vanderbilt, then at the zenith of his power as directing head of the New York Central system, visualized the south-tier route as an opportunity to extend his lines to the rich Pittsburgh steel district and to gain some of the freight that was being exclusively handled by the Pennsylvania Railroad. Having decided to make the move, he formed a $200,000,000 syndicate and launched construction at once. A 209-mile right of way was laid out from Harrisburg to Pittsburgh, and soon thousands of workmen were engaged in making the dirt and rock fly. By the summer of 1885 more than 60 per cent of the grade had been established.

Meanwhile, the interests in control of the Pennsylvania had become alarmed. Fighting back in kind, they started to build a railroad in western New York that would parallel the New York Central. That brought the rival factions together for a series of conferences, and peace was soon declared. Under the terms of the truce each group agreed to leave to the other the monopolies that then existed, in other words, not to invade each other's territory. That killed the South Penn Railroad. No hint of the negotiations had reached the construction camps, and the blow struck like lightning. Tools were laid down one night at the finish of a shift, and the following morning the workmen were discharged. The camps were closed. The Irish and the Italians that had been imported to build the railroad drifted away to other jobs. The roadbed was left for the wilderness to envelope it.

It is therefore not surprising that, after the passage of half a century, few persons in Pennsylvania should be aware of the fact that such a project had ever been conceived and begun. However, one man remembered it from his boyhood days, and out of that circumstance have grown the plans for the superhighway. The man is Edward Flickinger, chief of city planning in the Pennsylvania Department of Internal Affairs. To give him and his forebears their proper

places in this chronicle, we shall have to go back to July, 1778.

The Revolutionary War had just been fought, and Capt. John Flickinger, lately of General Washington's forces, was riding horseback along the eastern foothills of the Tuscarora Mountains, near the present location of Fort Loudon on the Lincoln Highway in western Franklin County, Pennsylvania. With no definite purpose in mind, he was making his way westward, seeking a place that struck his fancy where he might gain a start in life. It was dusk, and both man and horse were tired. They came to a fork in the trail. One branch led westward, up the steep mountain slope: the other extended on through the valley. Not knowing which course to take, Captain Flickinger elected to let the horse decide. With his hold on the reins relaxed, he touched his spurs lightly to the animal. His mount, with unerring horse sense, chose the easier route and continued on toward the north.

When darkness came, a few minutes later, man and horse stopped for the night. Upon awakening the following morning, Captain Flickinger found himself in beautiful surroundings and decided to remain there. It happened that another former soldier, Lieut. John Statler, was already in the valley. Captain Flickinger married his daughter, built a home on a grant of land, and raised a family. His descendants still own the farm, and some of them live there. The section is called Path Valley, the derivation of which is easy to determine. Nearby, if you will look on the map, you will locate Horse Valley, which, likely as not, got its name from the animal that was intelligent enough not to climb mountains when an easier course offered itself.

Edward Flickinger grew up on that farm. As boys, he and his brother, Joseph, played along the abandoned railroad route and swam in the pool of cool water that collected inside the east portal of Tuscarora Tunnel. From their grandfather they heard stories of the days when the region swarmed with construction gangs. Upon attaining manhood, Edward went to Harrisburg, started working for the state, and became interested in municipal planning. Joseph stayed on the family acres to help his father raise fruit.

In the summer of 1933, Edward spent a week-end at his old home, and the two brothers set out to revisit some of their boyhood haunts. As they walked along the abandoned railroad bed, they talked of the huge public-works program that was then being sponsored by the Federal Government, and the idea of utilizing the South Penn Railroad route as a highway occurred to them. Later, in Harrisburg, Edward often thought of it, and the more he dwelt upon the scheme the more sound it seemed to him. He mentioned it to two of his colleagues, Victor Lecoq and Sidney Snow, who also considered it feasible and worth while. Lecoq unfolded the plan to W. A. Sutherland, general manager of the Pennsylvania Motor Truck Association, who saw in the project an economical road for truck travel.

Although the cost of the undertaking was known to be of breath-taking proportions, various persons that were consulted expressed the belief that it was justified, and the Pennsylvania Planning Board began studying it in some detail. Among other things, its investigations led to the compiling of the first connected history of the route. During the early stages of the discussion, it was contemplated financing the construction of the highway with a grant from the Federal Government, but subsequent developments showed that another course was preferable.

In 1936, Cliff S. Patterson, representative of Washington County in the Pennsylvania Assembly, introduced a resolution authorizing a joint legislative commission to look into the merits of the proposed road. This was approved without opposition, and a commission of five members was appointed. After studying the data that had been gathered by the Planning Board, the commission authorized the making of an application for Works Progress Administration funds to be used, in conjunction with monies of the Pennsylvania Department of Highways, to finance a survey of the abandoned right of way. With long stretches of the old railroad virtually lost, it was necessary to reëstablish the line in order to de-

Pennsylvania Department of Highways Photo

A FILL SECTION

A stretch of the roadbed in Somerset County, showing what remains of the ties. Along many miles of the route are fills of this sort that will need only widening to make them fit for use in the new highway. Approximately 5,300,000 cubic yards of material that was moved by the railroad builders can be incorporated in the roadway, leaving about 9,400,000 cubic yards to be handled. In many places the old roadbed has been completely overgrown with trees.

STARTING A SOUTH PENN RAILROAD TUNNEL

This is a reproduction of an illustration that appeared in a catalogue published by the Ingersoll Rock Drill Company in 1885. It shows an "Eclipse" piston-type drill at the portal of one of the bores. All the tunnels were driven with drills of this kind. A table at the bottom of this page gives the progress that was made during the first part of the work.

termine the potentialities of the scheme.

The grant was forthcoming, and the survey was started under the direction of H. H. Temple, chief engineer of the Department of Highways. Ten crews, working a total of 72,000 man-hours over a period of thirteen months, not only ferreted out the old route but, from their field notes, plotted profiles and cross sections. Their studies revealed that the nine tunnels, with a combined length of 37,389 feet, were about 62 per cent excavated. These bores, the locations of which are shown on an accompanying map, are of interest now because they were among the leading large-scale rock-drilling undertakings of their day. All were designed to be double-track tunnels, 27 feet wide and 22 feet high, penetrating solid rock in which hard, gray sandstone predominated.

The drilling as done on that job was featured in an old Ingersoll Rock Drill Company catalogue which was issued in 1885. It contained data concerning seven of the tunnels, the other two being so short as to command little attention. The method of tunneling was to drive 8x27-foot top headings in advance of a bench 14 feet high and 27 feet wide. The drills were all of Ingersoll manufacture and generally of 3½-inch bore. They were operated with compressed air furnished by steam-driven compressors. Apparently, it was the general practice to generate steam with wood secured from the forests adjacent to the tunnel sites. One contractor reported that he burned from 48 to 50 cords of green oak and chestnut each week to supply steam for a compressor that operated ten drills.

In an accompanying table is given the progress made on the aforementioned seven tunnels from the beginning of the operations until February 1, 1885. As a basis of comparison with present-day progress in tunnel driving, this information will no doubt prove of interest to contractors. Up to that date, which was within a few months of the time work stopped, the average monthly advance at a double heading was 470 feet and at a single heading 225 feet. The best record for a week at a single heading was 74 feet and for a month 250 feet. The best progress on a bench was 54 feet in a week and 189 feet in a month.

As each of these tunnels, when completed under the present project, will accommodate only two lanes of traffic, it will be necessary to restrict the width of the highway at those points and to use one lane for cars traveling in each direction. With adequate supervision, however, this should not slow up traffic to any great extent. It will also be necessary, of course, to provide suitable means for exhausting gas from the tunnels and to supply fresh air at all times. In view of what has been done elsewhere in this respect, the matter of ventilation presents no great problem.

As an accompanying map shows, the proposed road will start at Middlesex, near Carlisle, and terminate near Irwin, which is a few miles east of Pittsburgh—a distance of 164½ miles. Connections will be made at both ends with established improved highways which will no doubt be reconstructed later according to the specifications of the new road so that the full stretch from Harrisburg to Pittsburgh will be standard.

Although there will be no great saving in mileage, as compared with existing routes

Record of Progress in Tunnels to February 1, 1885.

Name	Projected Length Feet	Progress Both Ends Sept. 6, 1884 Feet	Progress Both Ends Feb. 1, 1885 Feet
Blue Mountain	4,240	350	1,610
Kittatinny	4,620	850	2,280
Tuscarora	5,225	750	1,967
Sideling Hill	6,662	560	1,632
Rays Hill	3,534	570	1,234
Allegheny Mountain	5,900	1,060	2,230
Laurel Hill	5,400	700	990
Totals	35,581	4,840	11,943

Pennsylvania Department of Highways Photos

CONDITION OF TUNNELS

Considering that they were driven more than 50 years ago, the old railroad tunnels are in generally good condition. There has been considerable caving-in around the portals, but farther underground the sides and roofs have stood up well. The rock penetrated is mostly hard sandstone. It has been estimated that it will cost $400 per linear foot to complete the driving of the bores. The picture at the top, left, shows the east entrance to the Quemahoning Tunnel. The others show portals of the Allegheny Tunnel.

between the terminal points concerned, the superhighway will concededly save much time through the elimination of grades and curves. Present main roads have grades up to 9½ per cent, while the new one will have none greater than 3 per cent. A motor car traveling from Harrisburg to Pittsburgh now makes an aggregate climb of 13,880 feet. On the South Penn route it will amount to but 3,940 feet, which means a reduction of 9,940 feet. There will also be a considerable reduction in curvature. The new line is straight for 125 miles of its 164½-mile length, and its curves will be of such long radii that they can be negotiated in safety at any reasonable speed.

It is proposed that the highway shall have two strips of concrete, each 22 feet wide, separated by a planted zone. There will be no grade crossings of other highways or of railroads, and ramps will make it possible for cars to enter or leave it with complete safety. The location is such that a large part of the route traverses the southern or western slopes of hills. Because of this, and the fact that the highest elevation reached will be 2,400 feet—at Laurel Hill Tunnel, most of the prolonged ice and snow conditions in the wintertime will be eliminated, thus materially lowering the upkeep cost. The line is also high enough to remain unaffected by floods of the intensity of those experienced in 1936.

It is expected that trucks and buses will be required to use the new route, thereby taking them off the existing roads and making the latter safer as well as less expensive to maintain. At the same time it is believed that truck and bus operators will prefer the superhighway, as it will enable them to make better time and to operate at lower cost, even after paying tolls through the tunnels. With two traffic lanes in each direction, the presence of these heavier vehicles should not slow up other cars, and passing them should present little hazard. The legislative committee that studied the project estimated that a minimum of 5,000 cars a day would use the road; and it was on this basis that the annual income was estimated at $5,000,000.

The committee also arrived at some interesting figures regarding construction. It estimates that there will be required 392,000 tons of cement, 50,000 tons of steel, 1,200,000 tons of slag, and 770,000 tons of sand. The undertaking, based on statistics of highway building compiled by the U. S. Bureau of Roads, will furnish 18,980 man-years of direct employment and 32,365-man years of indirect employment. Grading will involve the movement of approximately 9,400,000 cubic yards of material, in addition to 5,300,000 cubic yards that was excavated by the South Penn Railroad and can be incorporated in the work to be done. The cost of completing the tunnels is estimated at $400 per linear foot, and that of the equipment for ventilating them at $1,500,000.

One of the leading arguments for the new highway is that it will be of value as a means of national defense. It is pointed out that it will make it possible to move men, munitions, and other materials of warfare speedily and efficiently. The proponents of the road also believe that it will spur the construction of similar highways and that the country will eventually be spanned by a high-speed, all-weather route offering motorists greater safety of travel than those now in existence.

TVA Scenes

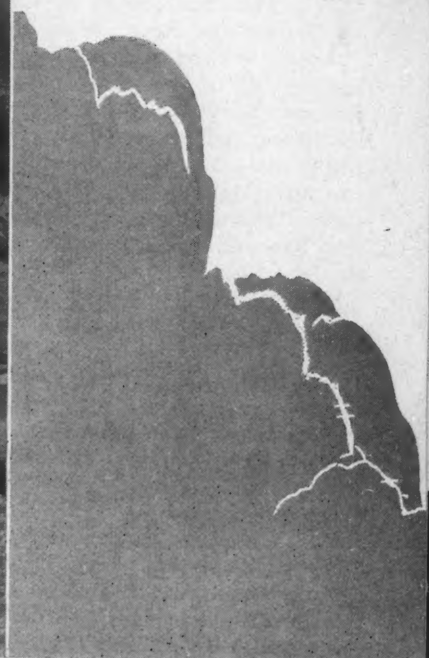
THE remolding of the Tennessee River is taking definite form as the program of the Federal Government goes into its fifth year of development. The large picture above shows Norris Dam, on the Clinch River, the first of the high dams to be completed. It is a gravity-type structure that rises 253 feet above the lowest foundation, is 1,872 feet long at the crest, and contains approximately 1,000,000 cubic yards of concrete. At full-pool level, its reservoir impounds 3,600,000 acre-feet of water and covers 83 square miles.

At the extreme right is a view inside the power house at the base of Norris Dam, showing the two 50,400-kw. generators each of which is driven by a 66,000-hp. turbine. Overhead may be seen the massive traveling crane that is used to move heavy pieces of equipment, and midway of the walkway at the left is the glass front of the control room.

By way of contrast with these examples of modern engineering is the photograph of the ox-drawn, wheelless vehicle which is in use on a mountain farm near the site of Hiwassee Dam, another high TVA structure that is under construction on the Hiwassee River near Murphy, N. C.

Photo by Rell Clements

Photo (c) by Rell Clements



The Valley of the Mohawks

Roy E. McFee

THE Mohawk Valley is the lowest pass through the Appalachian Mountains north of Georgia. Consequently it has become one of the great transportation routes of North America. Today, within its narrow confines are the six main-line tracks of the New York Central Railroad, two main highways, the Mohawk River-Barge Canal system, and the abandoned site of the old Erie Canal. And along the slender thread of these transportation arteries are strung industrial cities in close succession. Prominent among these are Schenectady, Canajoharie, and Utica.

But despite the industrial development, the valley retains something of the wildness and ruggedness of the remote past. Hills rise on both sides of the river and tower almost above the factories, while the wooded Adirondacks and Catskills loom in the distance. At Little Falls and again at Yosts, the narrowing ridges and sheer cliffs are evidence of the fact that the stream once broke through transverse mountain ranges of a still earlier geological age. Before the river cut its way through these uplifts, they actually divided the Mohawk Valley into three parts: Upper Mohawk, Middle Mohawk, and Lower Mohawk. The Upper and Middle Mohawks were really long lakes whose outlets at Little Falls and Yosts were in the form of waterfalls. The Lower Mohawk was a true valley through which the river flowed to the Hudson. Even now, at Little Falls, a normal drop of 40 feet is taken by the locks of the Barge Canal.

For perhaps a thousand years this region was a part of the domain of the Iroquois Indian Confederacy. These redmen were distinguished not only for their fierceness and treachery but also for their high intelligence. They lived, not in wigwams, but in long houses, substantial structures of wood built with the cross section of an ordinary garage but often of enormous length. These were divided into compartments for families. The Iroquois practiced agriculture, their orchards and cornfields frequently extending for miles.

The Iroquois Confederacy, or Five Nations, was the first political organization in the New World. As the name implies, it was a perpetual league of five Indian Tribes: Mohawk, Oneida, Onondaga, Seneca, and Cayuga. Each of these member tribes had its own organization, with its own chiefs. Generally it managed its own affairs. But for matters of peace and war, involving them all, the chiefs and delegates of the respective tribes gathered in the great council house in the Valley of Onondaga. There, in the words of the historian Parkman, "their council fire had burned from immemorial time."

In the days of its glory, the Confederacy could count 4,000 warriors. Through its numbers and superior organization it was able to pillage at will from New England to Michigan, and from Montreal to the far South. Its empire embraced what is now the best part of the State of New York; and its proud boast was that its territories had never known the footstep of an Indian invader. That was the power defied by the early white pioneers.

It was in 1614 that the canoe of the first white men ventured up the Mohawk River. They were two Dutch traders who found that pass securely in the possession of the Mohawks, the easternmost tribe of the Iroquois. Their villages were built along both banks of the river for a distance of 20 miles. The sites were carefully chosen, and the long houses arranged in rows, forming streets. The four most important villages were fortified with timber palisades and with protected platforms loaded with rocks ready for hurling down on an enemy during a possible siege. These fortified villages were called castles.

At that time there were in all four castles and four villages. The largest castle was Tenotoge. It stood 3 miles west of the present Village of Fort Plain and contained 55 houses, some of them 100 paces long. Altogether, this castle covered about 10 acres

THE BUSY MOHAWK VALLEY OF TODAY

A view taken from the north side of the valley, showing the 4-track main line of the New York Central in the foreground. Beyond are the river, the New York State Barge Canal, and two more New York Central tracks. There are also automobile highways on both sides of the valley. (Photograph by courtesy of New York Central System.)

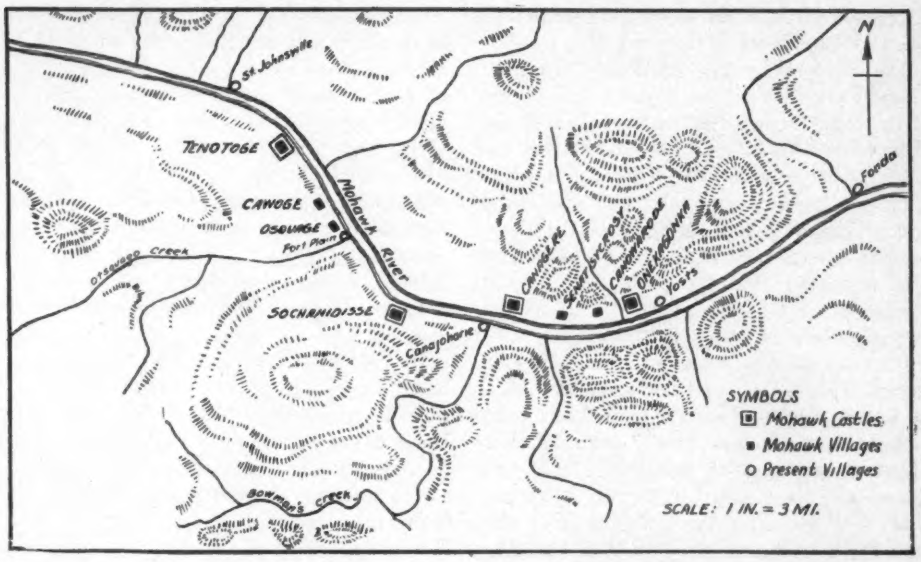
... land. Onekagonka Castle had 36 houses; Canagere, twelve; and Sochanidisse, 32. The four villages ranged from nine to fourteen houses each. All these castles and villages were connected by trails, along both banks of the river, extending east and west to serve as main Iroquois thoroughfares.

With the passing years the white settlements began creeping up the Mohawk. In 1661 Schenectady was founded by the Dutch. Under the advance of the white man's military force, the Mohawk castles were no longer impregnable, but liable to fall whenever a real clash came. As early as 1666 the four villages were destroyed, although their populations escaped. In 1693 the four castles were likewise burned—the three lower ones relatively easily, but the mighty Tenotoge only after a fierce struggle. With the destruction of the castles and villages on the Mohawk, the tribe retired to the forest, where it was to remain a menace for nearly a hundred years.

In the next century, Great Britain alertly recognized the importance of the Iroquois in its struggle with France for the possession of the North American Continent. Accordingly it sent over Sir William Johnson as ambassador to the Five Nations. Sir William constructed on the north bank of the Mohawk River a baronial mansion that still stands at Fort Johnson with its portholes looking out on all four sides. There he maintained the dignity of his sovereign, and dispensed royal hospitality to the Mohawks. Indians filled his dooryard, crowded about his table, and slept in his very halls. He was able to keep them loyal throughout Pontiac's conspiracy. He made a special charge of Joseph Brant, young war chief of the Mohawks, and sent him to school. Sir William died on the brink of the Revolutionary War. His last words to his protégé were, "Brant, restrain your people." That, however, was not to be, as events swiftly proved.

The outbreak of the Revolution made the Mohawk Valley an immediate battleground. The Iroquois Confederacy promptly threw its might on the side of the British, and the struggle for the Mohawk Pass had to be fought again. In 1777 an expedition of British soldiers and Iroquois Indians began marching down the river, intent on laying the valley to waste and then joining Burgoyne at Albany. General Herkimer and his army of Mohawk Valley farmers moved westward to meet the enemy. The encounter came in the Forests of Oriskany. There, from morning until night, the hand-to-hand struggle continued. It ended with the Americans in possession of the field and with the invasion turned back. The loss of life had been great. General Herkimer had perished on the field of glory, and the soldiers themselves had achieved a fame to be told to this day by their descendants in the region.

Ten miles south of the river the little hamlet of Cherry Valley had been founded on the first rise of the Catskills. All about it, wooded peaks threw their shadows across the cabin roofs. One autumn day in 1778, Joseph Brant and his party of Mohawks peered out from the summit of Campbell's Mountain to reconnoiter before descending upon the place. It happened that some boys with sticks were playing soldiers in the street. Brant mistook them for actual soldiers, and delayed the attack. A few days later he returned, however, and massacred the whole village.



OLD MOHAWK INDIAN SETTLEMENTS

The Mohawks, one of the five nations comprising the Iroquois Confederacy, had this section to themselves prior to the coming of the white man. There they built four fortified strongholds, or castles, and four villages which were impregnable to their Indian foes. Their reign ended in 1693, when the castles were burned by the white settlers.

The Iroquois stronghold had been moving steadily back into the forests south of the Mohawk. With the Indians striking unexpectedly and at random, the whole Mohawk frontier was threatened, and no family was safe. Consequently, in 1779, it was determined to send a strong American force into the Indian country. The entire plan was carefully worked out by General Washington himself. Altogether it represented a brilliant and novel stroke of military engineering. General Sullivan with 3,000 men was to ascend the Susquehanna River from Pennsylvania. Meanwhile General Clinton with 1,500 men was to ascend the Mohawk River and proceed overland and down the Susquehanna. Near Binghamton they were to join forces and engage the Iroquois at close quarters.

The truly unusual part of the expedition was that delegated to General Clinton. In accordance with the plan, he moved his army—including more than 200 heavy flat boats and numerous pieces of artillery—up the Mohawk and landed them at Canajoharie, where he started cutting a road through unbroken forest toward the north end of Otsego Lake. Then by means of ox-carts and horse-drawn wagons he transported his boats and equipment under heavy guard over the 20 miles to that point. From there his fleet leisurely sailed the 9 miles to the lower end of the lake, at the present site of Cooperstown. At that spot was an outlet, which was really the beginning of a branch of the Susquehanna. However, the ordinary flow of the stream was not sufficient to carry the flatboats. So Clinton ordered the construction of a dam across the waterway and held his forces while the lake level rose. When he thought there was ample water in reserve, he assembled his fleet, completely manned and equipped, above the dam. When all was in readiness, the dam was knocked out and the craft were borne along with the flood. Great indeed was the dismay in the Indian country. Devastating waters rolled without warning through their sunlighted forests and across secluded cornfields, and on the crest rode such a fleet as their eyes had never witnessed, bearing an army of whooping men and bristling cannon. Clinton met Sullivan as planned, and together they routed the Iroquois in their own stronghold.

The end of the Revolution was a catastrophe for the Iroquois. They had gambled and lost, not only their warriors and their prestige but their homes and lands as well. They knew that the withdrawal of the British left them completely at the mercy of the colonists, who had not forgotten the outrage of Cherry Valley. The proud race acted with characteristic decision and promptness. They launched their canoes, bade a silent farewell to their ancient forest empire, and left for Canada, never again to return.

The ending of the war and the departure of the Iroquois changed the entire aspect of the Mohawk Valley. It was transformed almost at once from a contested pass to a potential highway of commerce. When Washington toured the region on horseback in 1783, tranquillity was established and revival stirring. The year 1800 saw the building of the Mohawk Turnpike from

Schenectady to Utica along the Indian trail on the north bank of the river.

In 1825, Governor DeWitt Clinton of New York finished the construction of the Erie Canal. It was the first real transportation system in America, and connected the Hudson River with Lake Erie. When it was first proposed, Governor Clinton was asked derisively whether he could cause the water to flow up and down hills and across rivers. He answered that he could, and would make it carry boats as well. And to the astonishment of many, he did exactly that by means of stone masonry aqueducts and locks. The canal was built originally with a water depth of only 4 feet, which was subsequently increased to 7 feet. At that depth it had a surface width of 70 feet and permitted the passage of boats of 240 tons. For 90 years after the completion of the canal, the valley was to see mules plodding along the towpath in seemingly endless procession.

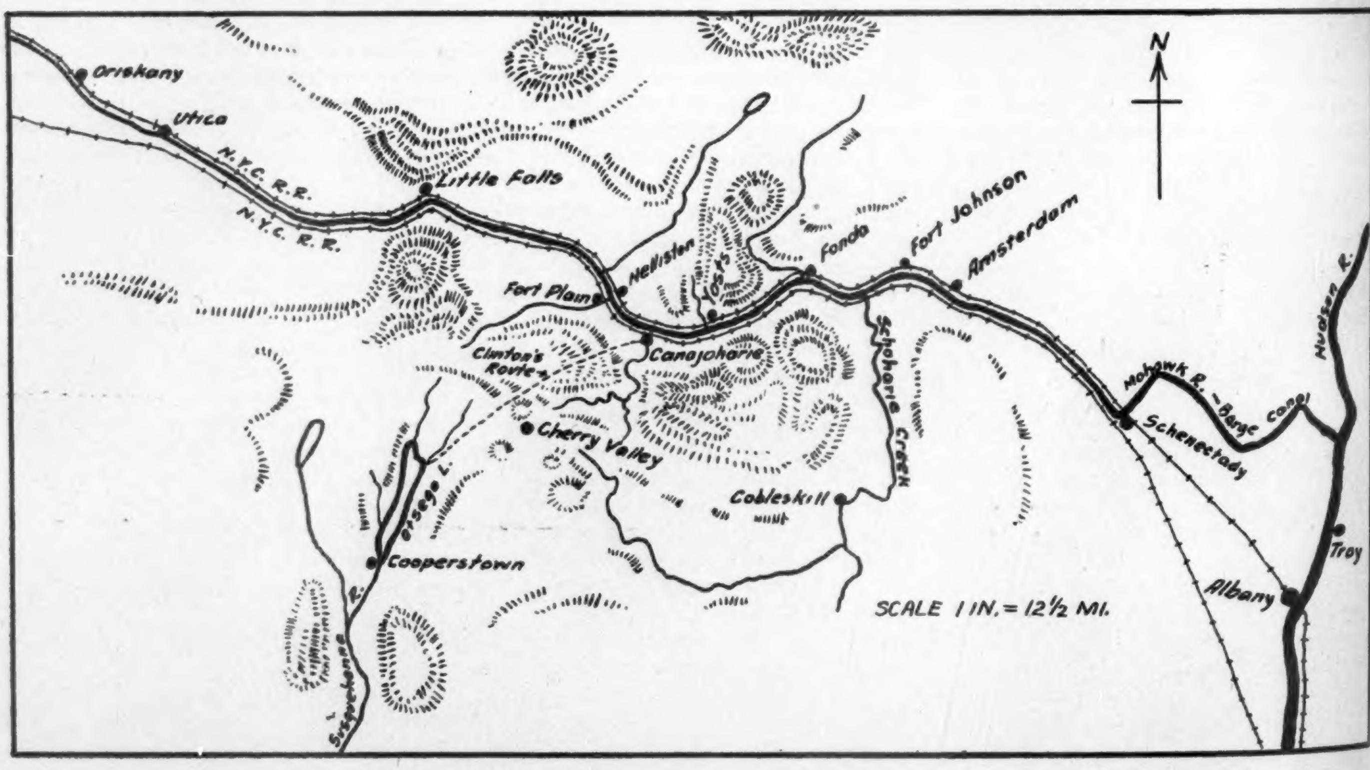
But in 1831 came another change. That year marked the opening of the Mohawk & Hudson Railroad. It ran between Albany and Schenectady, and was the first steam passenger road in America. The line from Schenectady to Utica was finished in 1836. Later, both of these routes became the New York Central & Hudson River Railroad. That was when Commodore Vanderbilt combined fourteen railways, end to end, in order to extend his system from New York City to Buffalo.

This transportation system traversed the Mohawk Valley on the north bank of the river and alongside the turnpike. In 1883 the West Shore Railroad was completed on the south bank. This has been acquired since by the New York Central, giving the latter four tracks on the north and two tracks on the south side of the Mohawk. The 4-track line is the route of such famous trains as the *Twentieth Century Limited* and the *Empire State Express*. Where the Mohawk war whoop once resounded, the whistle of trains now echoes instead.

In 1911 a modern "eagle" tried the Mohawk Pass. That was the year of the historic airplane flight of Atwood from St. Louis to New York City. On a bright day in August he flew from Syracuse to Nelliston, a distance of 95 miles, continuing his flight the next day to Castleton on the Hudson, a stretch of 65 miles. It is recorded that when he landed his airplane in a field at Nelliston, one of the inhabitants rushed breathlessly to the scene. Desiring to know his whereabouts, Atwood asked him, "Would you please tell me where I am?" "Certainly," courteously replied the native, "you are in Charlie Knowles' cow pasture."

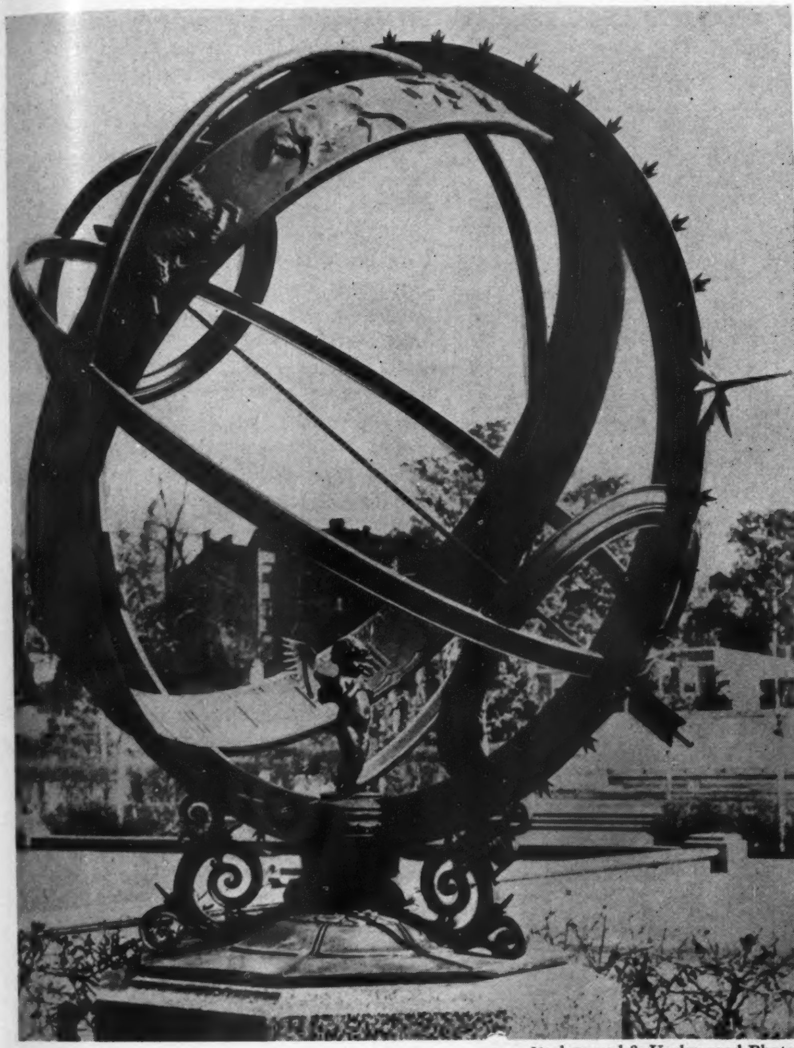
Twenty years ago the conversion of the Erie Canal into the Barge Canal was completed. That was done at an added cost of $200,000,000. The new waterway is 12 feet deep, with a much widened channel and extensive port facilities. The towpath, mules, and clumsy canal boats are but a memory now. Instead, the valley sees 1,000-ton barges running under their own power to the distant lake ports of Duluth and Chicago. The Barge Canal follows the route of the old Erie for only half its length. Reaching the Mohawk Valley, it flows in the dredged channel of the Mohawk River, the waters of which are controlled by dams, gates, and locks. There the abandoned bed of the Erie, where it passes through cities, is now serving sometimes as a low-level boulevard and at others as a site for factories, schools, and similar structures. But generally, in the open country, it lies an abandoned ditch, the empty and lifeless shell of the once-famed Erie.

Today the Mohawk Pass hums with activity. Boats ply its river-canal. Trains with millions of passengers and millions of tons of freight rumble over its six railroad tracks. Airplanes on regular schedules follow it through the Appalachian barrier. But perhaps more important still, continuous streams of automobiles yearly carry multitudes of travelers and tourists along its two water-level thoroughfares. What the future will bring no one can foresee. The Mohawk Valley has been proposed as the route of an all-American seaway. Even if the St. Lawrence River is so developed, this other seaway may some day be built as well. If this should come to pass, the Mohawk Valley will witness still stranger sights than it has in the past, for then ocean-going ships will glide over its erstwhile cornfields and apple orchards and down its ancient Iroquois war trails.



MAP OF MOHAWK VALLEY

Before the mountain barriers at Yosts and Little Falls were entirely cut through by the waters of the Mohawk, the Upper Mohawk Valley consisted of two long lakes. Even today there is a drop of 40 feet at Little Falls, necessitating the use of locks at that point on the Barge Canal. The dotted line shows the route taken by General Clinton in 1779 to meet General Sullivan, who had ascended the Susquehanna River from Pennsylvania. Together, they routed the Iroquois, who left for Canada and never returned, thus relinquishing lands they had held for hundreds of years.



Underwood & Underwood Photos.

ARMILLARY SPHERE

One of these rings is a sundial: the others represent the positions of important great circles on the celestial globe. The sphere stands in Meridian Hill Park, Washington, D. C. A table of adjustments, calculated at Columbia University, makes it possible to determine with accuracy the time of day at various seasons of the year.

Telling Time by a Shadow

William S. Powell

AN ANCIENT TIMEKEEPER

Sundials seem to have been used at an early period in all parts of the world that had attained culture. The one shown here, which gives evidence of great antiquity, stands in a monastery at Kirin, in Manchuria.

SOME articles of utility possess a simple beauty of form that gives them great charm. Among these is the sundial. In most parts of the world, watches, clocks, and tolling bells have robbed it of its usefulness, but, nevertheless, it retains a measure of popularity as an object of outdoor decoration by virtue of its aesthetic appeal.

The sundial is of very ancient origin and served as a chronometer through the ages. Even as late as the early part of the nineteenth century, children in the common schools of the United States were taught dialing along with navigation and land surveying. Some of our first money bore a representation of a sundial. On it were the words "Fugio," and "Mind Your Business." It appeared first on dollars that were cast in silver, bronze, and pewter, later on the copper cent, and then on a paper note of one-third of a dollar face value. It even was printed on some of the fractional currency issued by the City of New York. Because of the motto they carried, the dollars went under the name of "Fugio dollars." They were also known as Franklin dollars, as they were first circulated when Benjamin Franklin was postmaster-general. It is almost certain that he had a hand in their design, as he had lived for some years in London where a sundial on the general post office bore the motto, "Be About Your Business." The origin of this phrase is an interesting story in itself.

It is reported that an English dialmaker had been commissioned to fashion a dial for a certain library in London. When the work had progressed to the proper stage, he called at the library to find out what motto he should inscribe upon its face. An irked attendant who knew nothing about the matter dismissed him with the curt remark, "Begone about your business." The artisan put the words upon his dial and delivered it. The motto was considered such a good one that it was engraved, sometimes in modified form, on many others. Incidentally, a motto was regarded as an essential embellishment. One writer on the subject collected and published more than 1,600 that had been observed on dials in this country and abroad. The custom has persisted, and most modern decorative dials bear some appropriate inscription.

Dials made in past centuries were of many kinds, some simple and some intricate. In Shakespeare's time, pocket dials were very popular. While they were not so accurate as a modern watch, they were entirely adequate for an era when life was more leisurely than it is now and there were no trains to catch. Larger dials were sometimes very elaborate, and not only told the time of day but also the month and the year. Dialing, or gnomonics, was a subject that engrossed men of a scientific turn of

Ewing Galloway

NEARLY 200 YEARS OLD

This vertical sundial has told time in Santo Domingo, Dominion Republic, since 1753, when it was erected by the Spanish governor of the island.

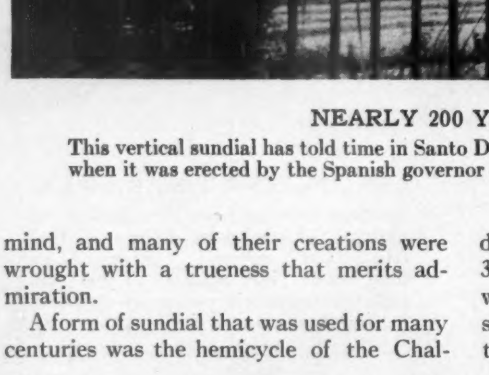
mind, and many of their creations were wrought with a trueness that merits admiration.

A form of sundial that was used for many centuries was the hemicycle of the Chaldean astronomer Berossus, who lived about 300 B.C. It was a hollow hemisphere that was set with its rim horizontal and had a small bead suspended at the center. During the sun's progress, the shadow of the bead described an arc that was divided into twelve parts. These were called "temporary hours," because their length varied with the seasons. Temporary hours continued in force for about 1,600 years until clocks appeared around 1400 A.D., when "equal hours" began to be observed.

The ancient Greeks learned the art of sundialing from the Babylonians, and made such progress in mathematics and astronomy that they were soon able to construct dials of great complexity, some of which have been handed down to us. The Arabians, in turn, were taught gnomonics by the Greeks, but their sundials were, for the most part, simple. Dialing was discussed at great length in the seventeenth century by writers on astronomy. In 1612, Clavius published an 800-page book which is said to have included virtually everything that was known on the subject up to that time.

Dialing is based on the two motions of the earth—daily and annual. As we all know, once every 24 hours our globe turns on its axis from west to east, and in a year it travels around the sun. To us, however, the earth's movements are not perceptible, and it seems, rather, that the sun and stars revolve around the earth's axis once each day. In this apparent procession the sun lags a little behind the stars. The interval increases daily until the sun's day is four minutes longer than an actual day, as measured by a watch. The sun then picks up a little of the lost time each day until it regains it all. This retardation of the sun makes time as told by the sundial irregular. Watch time is called mean time, and dial time apparent time, and the difference between the two the equation of time.

On four days of each year the sun agrees with your watch. Those days are April 15, June 15, September 1, and December 24. In setting up a dial, it is essential that the noon mark or meridian be established as accurately as possible, and it is best, therefore, to choose one of the aforementioned days for that purpose. If at exactly 12 o'clock you cast a shadow and outline its path, the line between the marks will run in a true north and south direction. If you prefer, however, you can establish the meridian just as accurately on any clear



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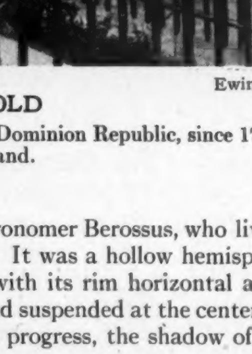
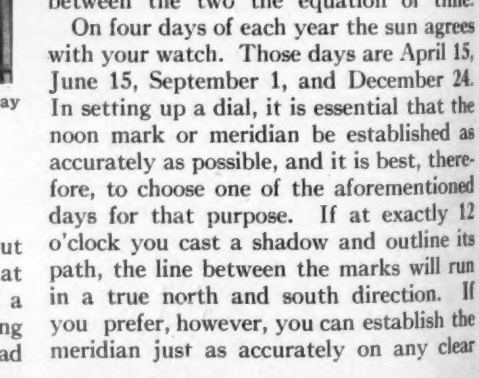


CAROLINE RISQUE



MRS. G. M. MOORE

night. To do this, hang two plumb lines, and move one of them about until when you sight along them you are also sighting the North Star. Then drive stakes where each plumb bob touches the ground, and the line connecting the stakes will be the meridian.

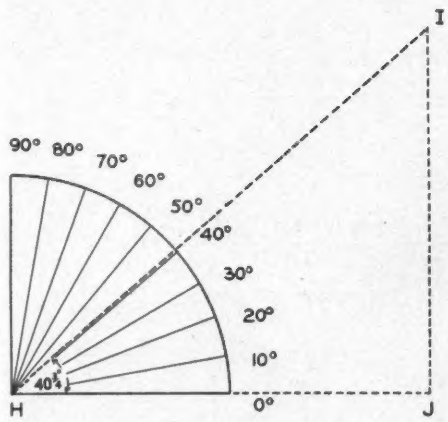
There are three general classes of sundials: horizontal, vertical, and inclining. A vertical or inclining dial that does not face squarely toward one of the four points of the compass is called declining. If the plane is inclined so that its top is farther forward than its base, it is said to be proclining. If the opposite is true, it is reclining. Many variations of these more common forms existed in the past. There was the refractive dial which, as the name implies, depended upon refracted light. Similarly, reflective dials made use of light reflected by a mirror. Pocket dials were frequently cylindrical in shape, and usually had a detachable gnomon that rested inside the cylinder when it was in the owner's pocket.

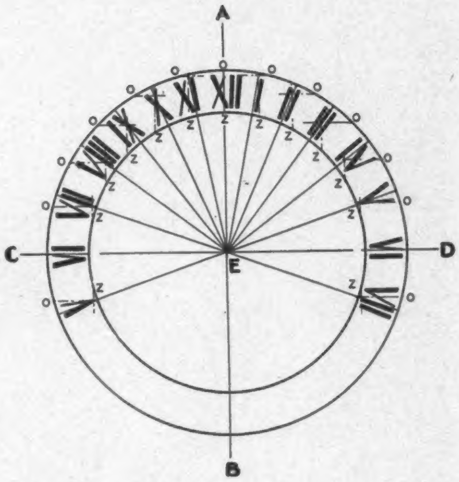
An ordinary horizontal sundial has only two parts: the plane, on which the hours are marked, and the style or gnomon, which is erected upon the plane in such a manner that its shadow will be cast upon the plane and thereby indicate the time. The gnomon may be only a fine wire; but more often it is a triangular plate mounted perpendicularly upon the plane along the line that is known as the substyle. Sundials that are erected in a fixed position—on a building, for example—are called stationary, while those that may be moved freely are termed portable. In a great part of the United States and Europe, where the sun rises as early as four o'clock and sets as late as eight o'clock on the longer days of the year, dials are usually numbered according to that range.

To get an understanding of the principle of dialing, assume that the earth is a transparent glass sphere. Then divide the equator into 24 equal parts and draw upon the surface of the sphere 24 semicircles, each extending from pole to pole and passing through one of the division points on the equator. These will constitute geographical meridian lines. Assume that one of them passes through New York City. Where that line and the one directly opposite it on the globe intersect the equator, place the numeral twelve. The various meridians between the two will then become the hour circles for New York City.

Next suppose that the earth's axis running from pole to pole is of solid, opaque material. When the earth has turned to the point where the sun is directly in line with the plane of the two 12-o'clock meridians, then the axis will cast a shadow that will fall upon the figure twelve on the far side of the globe. Similarly, as each hour passes, and as the earth rotates, the shadow will fall in order upon the other hour numerals.

Now, if we cut through the upper half of





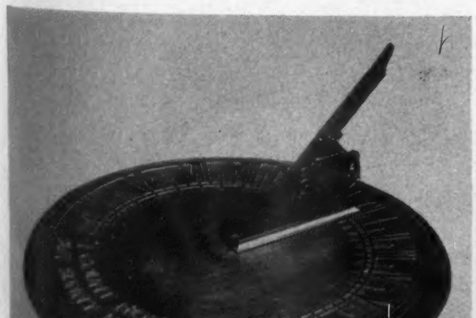
HOW TO MAKE A HORIZONTAL SUNDIAL

Assuming that the dial is to be set up in New York City, the approximate latitude of 40¾ degrees determines the angle of inclination of the stile or gnomon, which casts the shadow. First draw the base line *HJ*, in the figure at the left. Then, with a protractor, establish the angle of 40¾ degrees and draw the line *HI* through it. Drop the perpendicular line *IJ*. The triangle thus formed constitutes the simplest gnomon.

For the face of the dial (right), draw the lines *AB* and *CD* at right angles to each other. With their intersection *E* as the center, draw a circle having a radius equal to the length of the line *HI* in the figure at the left. From the same center draw another circle having a radius equal to the length of the line *HJ*. The points *C* and *D* will be six o'clock points, and *A* will be the twelve o'clock point. Next, on the outer circle, divide the lines *AC* and *AD* into two equal parts and subdivide each of these into three, so as to make twelve equal parts. Mark the division points *o*. Do the same with the inner circle, and mark the division points *z*. Draw dotted lines parallel to *CD* from the points marked *o* in the upper half of the circle, then draw lines parallel to *AB* from the points marked *z* on the inner circle. From the center *E* draw straight lines through each intersecting point of the two sets of lines just mentioned. These will be the hour lines of the dial, and where they cross the circles will be the hour points. Locations of hour points in the lower half of the circle can be determined in the same way.

The gnomon should be erected on the line *EA* and with the point *H* at point *E*. If a thin gnomon is used, say 1/16 inch through, no allowance need be made for its width. In the case of a thicker one, however, a dial made by these directions will not be accurate.

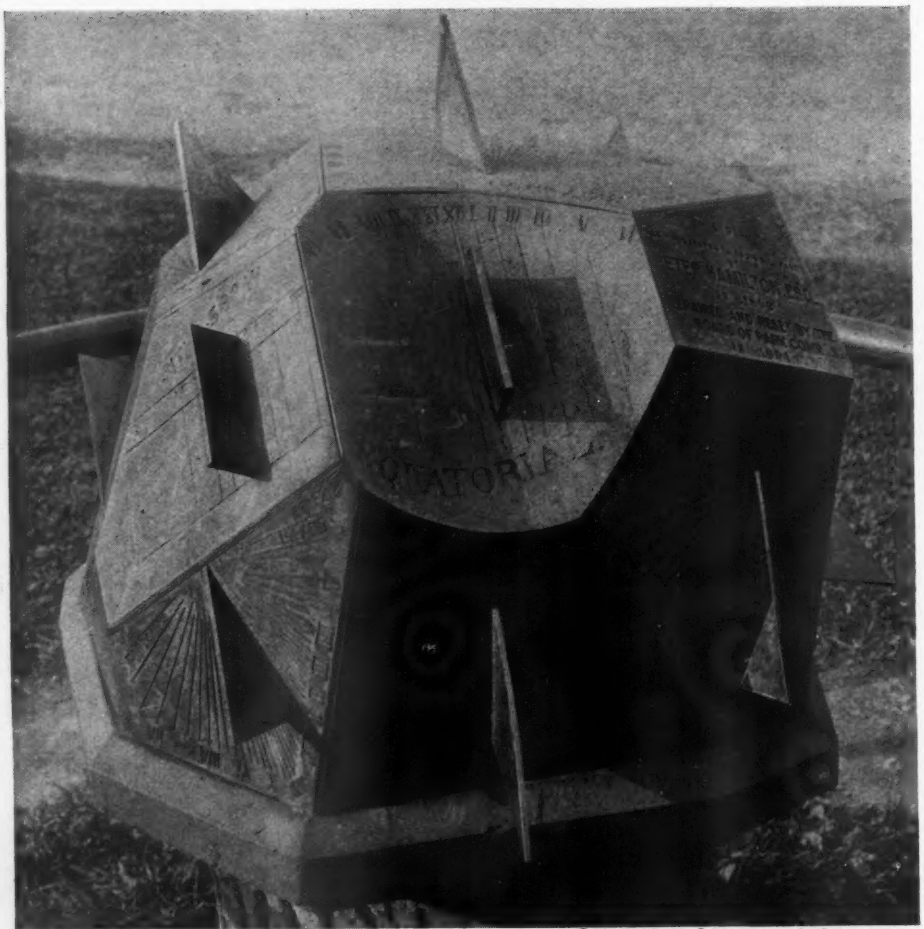
The dial should be set up so that the plane is in a true horizontal direction, with the line *AB* running true north and south. The north and south line, or noon mark, can be found by casting a shadow with a thin perpendicular upright exactly at noon. The gnomon will be parallel with the earth's axis, and the dial will be reasonably accurate for all points in the same general latitude as New York City. These include Newark, N. J., Pittsburgh, Pa., Columbus, O., Indianapolis, Ind., Omaha, Neb., Denver, Colo., and Salt Lake City, Utah. If you prefer, you may set up the dial after you have determined the six o'clock and twelve o'clock points, and mark the intermediate hour points where each is indicated by the shadow at the precise time in each case, as indicated by a watch.



THE GORHAM COMPANY

V. E. RICHARDS

HERBET M. DAWLEY



Keystone View Company

TELLS TIME IN MANY LANDS

By inclining the face and gnomon so that they will be at suitable angles, it is possible to set up a sundial that will tell what time it is at any point on the globe. This multiple dial stands in Druid Hill Park, Baltimore, Md., and gives the hour of a dozen different locations.

the sphere, with the solid plane at the rational horizon of New York City, and draw straight lines from its center to each of the points where the meridians pass through its circumference, those lines will be the hour lines of a horizontal dial for New York City. This is true because the shadow of the axis will fall upon each particular hour line of the dial when it falls upon the like hour circle of the sphere. If the plane is erected vertically, touching New York City, and is directly facing the meridian of that place, it will become the plane of a vertical direct-south dial for New York City. The hour numerals will be at those points in the lower section of the sphere where straight lines drawn from the center intersect the respective meridians. Similarly, if the plane is proclined or reclined a certain number of degrees, but is still directly facing the meridian, the hour marks will be at those points where the radii cross the respective hour lines.

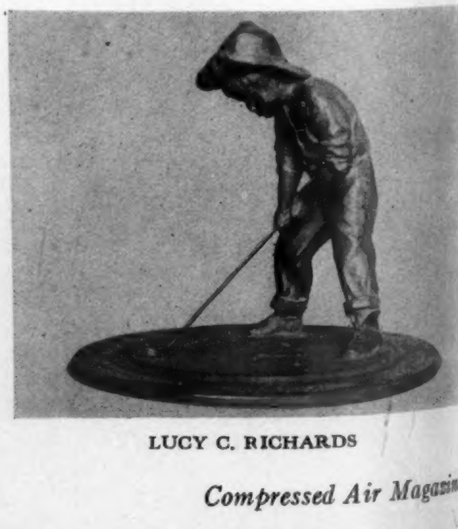
It will thus be seen that the plane of every dial is in reality the plane of some great circle described upon the earth, and the gnomon represents the earth's axis, whether it be a fine wire or the edge of a thin plate. Since the earth, with respect to its distance from the sun, is but a small point in the universe, if any small sphere be placed anywhere upon the earth's surface, with its axis parallel to that of the earth and marked as previously directed, it will show the hours of the day as correctly as if it were in reality at the center of the transparent full-sized sphere that we used for our illustration. Then, if we simply take a plane cut across the small globe, it, too, will tell time truly, provided due allowance be made for the latitude of the place of installation when the elevation of the gnomon is determined. If the dial is horizontal, the gnomon forms an angle with the plane exactly equal to the latitude at that particular point. If the dial is a vertical one, the angle will be equal to the colatitude, which is obtained by subtracting the latitude from 90 degrees.

With these fundamental facts in mind, it is a relatively simple matter to construct a fairly accurate dial. For those who are sufficiently interested, accompanying illustrations indicate how this may be done without resorting to instruments more complicated than a ruler and protractor. The professional dialmaker determines the positions of the hour numerals by mathematical calculation.

The first sundial of historical record was that of Ahaz, who ruled as King of Judah in the eighth century, B.C. Having been warred upon by the kings of Syria and Israel, he made an alliance with the Babylonians, whose religion he accepted as one of the terms of the agreement. The Babylonians were the first people to divide time by mechanical apparatus; and only nineteen years prior to the accession of Ahaz to the throne they had rectified their calendar. They used sundials, which Ahaz seems to have adopted along with their religion. An apparent miracle in connection with the sundial of Ahaz is set down, as follows, in Isaiah xxxviii.8:

H. W. FRISHMUTH

E. E. GOODMAN



LUCY C. RICHARDS

"Behold, I will bring again the shadow of the degrees which is gone down in the sun-dial of Ahaz, ten degrees backward. So the sun returned ten degrees by which degrees it was gone down."

The explanation is found in the character of that particular sundial and the manner in which it was used. A replica of the dial of Ahaz, or Horologium Achaz, reposes in Philadelphia, having come down to the American Philosophical Association through Benjamin Franklin. It was originally brought to this country by members of the strange religious sect of Rosicrucians from Germany, where it was wrought by Christopher Schissler, a great mathematician of his day and a master worker in brass. This dial is in the form of a basin, which has the numerals disposed about the upper part of its sides. It bears many figures and inscriptions, and among the latter is one in Latin which has been translated as follows:

"This semicircular shell explains the miracle of the 38th chapter of Isaiah. For if you fill it to the brim with water, the shadow of the sun is borne backward ten or twenty degrees."

Thus a supposed supernatural happening is found to have been merely the action of refracted light.

Reflecting sundials make it possible to tell time indoors during hours of sunshine. Isaac Newton is reported to have made such a dial when he was a boy. He placed a bit of mirror in a horizontal position on a window sill so that it would cast a spot of light upon a dial face which he had painted on the ceiling of the room.

Keystone View Company

A STREET DIAL

This disk, painted on a street in Walla Walla, Wash., enables a person to learn the approximate time by standing in the center and observing his shadow.

A great many of the dials that have come down through the centuries are of the vertical type. By using that form they could be mounted in lofty positions, where they would be safe from mischievous boys or other tamperers. Thus we find them on churches over doorways, or on crosses atop the structures; on corbels, gables, or buttresses of buildings; and on tall pedestals of metalwork or shafts of stone. Some were at the corners of buildings, the face being divided into two planes at right angles to each other.

In the British Isles, where there is no great variation in latitude, a dial made for one place would give fairly accurate time anywhere else, and, as a result, the manufacture of dials attained considerable magnitude. It was the common practice for tombstone carvers to fashion dials in their spare time. The colonists found American spaces so vast, however, that dials had to be built for the latitudes where they were to be used. This mitigated against their production on a quantity scale, although several firms were engaged in the business of turning them out. It was the general thing for settlers to make their own dials, for, as already recited, knowledge of the manner of doing this was disseminated through the common schools.

Many men of prominence in early American affairs were deeply interested in dialing. In her book *Sun-dials and Roses of Yesterday*, which has been drawn upon for many of the facts presented in this article, Alice Morse Earle reproduces a letter written by Thomas Jefferson to a friend on August 23, 1811. While confined to the

J. SELMAR LARSON

J. SELMAR LARSON

LUCY C. RICHARDS (c)

Underwood & Underwood

WORLD'S LARGEST SUNDIAL

This is located on the campus of the University of the Philippines at Manila. As will be notéd, it is large enough so that time can be observed to the minute.

house by an attack of rheumatism, he had amused himself by calculating the hour lines of a horizontal dial suitable for the particular latitude of his Virginia home, *Poplar Forest.* In connection with that dial he wrote:

"The calculations are for every five minutes of time and are always exact to within less than half a second of a degree. As I do not know that anybody here has taken this trouble before, I have supposed a copy would be acceptable to you. It may be good exercise for Master Cyrus to make you a dial by them. He will need nothing but a protractor, or a line of chords and dividers. A dial of size say of from twelve inches to two feet square, is the cheapest and most accurate measure of time for general use, and would I suppose be more common if every one possessed the proper horary lines for his own latitude. Williamsburgh being very nearly in the parallel of the Poplar Forest, the calculations now sent would serve for all the counties in the line between that place and this, for your own place, New London, and Lynchburg in this neighborhood. Slate, as being less affected by the sun, is preferable to wood or metal, and needs but a saw and plane to prepare it, and a knife point to mark the lines and figures. If worth the trouble, you will, of course, use the paper enclosed; if not, some of your neighbors may wish to do it."

The world's finest dials, many of them still remaining, were built and erected in Scotland. The most beautiful of all is generally considered to be the dial of Glamis, which stands on the grounds of Glamis Castle. It is in the form of a monument more than 21 feet high. Just above its base are four rampant lions facing the four points of the compass and each holding a vertical dial. Some 4 feet above these figures is a head with 24 facets each of which has three or four dials, making more than 80 dials in all. This structure was set up sometime prior to the year 1600.

Yankee ingenuity seems to have hastened the end of the dial in this country, so far as its practical application is concerned. Even when Europeans were still relying chiefly upon the sun's shadow for telling time, Connecticut clocks were being turned out at such a low cost that they were within the reach of most American households. Thus the teaching of dialing in the schools became unnecessary, and the subject was dropped from the curriculums on this side of the Atlantic considerably earlier than abroad.

In addition to their inherent beauty, sundials fascinate many persons because of their indefinable quality of mysticism. Time being such an intangible thing, it is peculiarly fitting that it should be measured by something just as intangible—a shadow. There is something appealing about the idea of using the sun's rays, rather than springs and gears, to mark the passing hours. For these reasons, sundials are still in demand, even in this country. Most of them are set up where the surroundings are harmonious, favorite locations being gardens, parks, country estates, golf courses, and the like.

Surprising as it may seem, Thomas's Register of American Manufacturers lists 26 firms in the United States that make sundials. The volume of business is hardly sufficient, however, to assure any company a dependable income from that source alone, and with most of them their production is a side line that fits in well with other activities. Modern sundials may be procured in brass, bronze, aluminum, stone, porcelain, glass, and other materials, and are, in many instances, made especially to conform to the natural setting chosen for them. At the bottoms of the four preceding pages are shown various examples of this type cast in bronze by The Gorham Company of Providence, R. I., and reproduced through the courtesy of that firm. Under each is the name of the artist or sculptor. These dials are small, their base and height ranging from 10 to 20 inches.

Using Compressed Air as a Booster

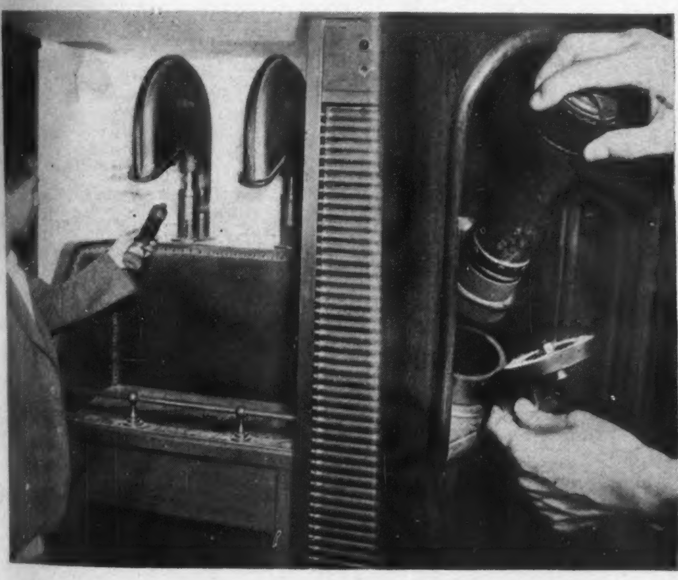
KEEPING water mains sweet and clean to the satisfaction of consumers represented somewhat of a problem in sections of Stockton, Calif., until the management of the California Water Service Company conceived the idea of putting more pressure behind the water used periodically to flush certain of its mains.

Stockton, like some other towns in the United States, developed without much thought to the future, and has many 2-inch water mains in the less populated districts. In the past it was the practice to give them, together with all dead ends, a regular cleaning about once every other month by allowing water at the normal pressure of 45 pounds to flow through them until it issued clear from fire hydrants and risers. The latter had been especially provided for the purpose at all dead ends, regardless of their size, and about every other block throughout the length of the 2-inch lines. However, aside from freshening the supply at those points, nothing more was achieved: the algae and other matter that affect the taste of and impart an objectionable odor to water still clung to the pipe walls.

Complaints were numerous and justified. To remedy the situation, the company decided to put more force behind the flushing water so as to give it a scouring action and thus remove the troublesome deposits. And this is how it is boosting the pressure and achieving the desired result. Midway between two risers compressed air is admitted into the line through one of the existing service connections after the shut-off valves on all the other intervening connections have been closed. The air used is at a pressure of 90 pounds, and forces the water in the particular section out through one of the risers. As soon as it has been expelled, the air supply is turned off and water under normal pressure run through to wash out the loosened material by what R. F. Brown, the company's plant manager, calls "air shooting." These operations are repeated until the water flowing out of the riser is clear and free from suspended matter.

Something like 40,000 feet of line, mostly of 2-inch diameter, was cleaned by this method within a span of two months at a cost of from 60 to 90 cents per 100 feet, depending upon the number of service connections which had to be turned off and on again. That the treatment is successful is evidenced by the absence of complaints from consumers not only as to the taste and odor of the water but also as to its pressure. The increase in the carrying capacity of this part of the system had not been foreseen, and is the direct result of the removal of the incrustations from within the pipe. How soon the procedure will have to be repeated has not yet been determined, but obviously not as frequently as in the past.

Pneumatic Tubes Carry News from Japan's Diet



EXPEDITING THE NEWS

The imposing new structure where Japanese lawmakers convene, and views of the pneumatic-tube system that transmits news dispatches from the press gallery to a room near an exit where "copy boys" receive them. In the lower right-hand corner is a section of the press gallery with seats for the public in the balcony above it. In the paneled back wall of the gallery are seen some of the openings to the tubes. Above, left, a carrier is being dispatched while another is shown immediately upon arrival in the receiving room.

A FEATURE of the fine new $8,000,000 building of Japan's national legislative body, the Diet, in Tokyo, is a pneumatic-tube system for the use of the newspaper reporters who attend the sessions. Through it, dispatches are transmitted from the press gallery to a room near an exit of the building, where they are received by messengers who deliver them to the various newspaper and press-association offices of the city.

The press gallery has accommodations for 300 reporters, and is the largest and most modern one in Japan. It is located between the seats occupied by the Diet members and those reserved for the public. Openings to the tubes are spaced at convenient intervals in the paneled wall that is seen immediately behind and above the gallery.

The system was used for the first time this year, and has operated with complete success. Its institution has caused the disappearance of scores of "copy carriers" from the Diet chambers, thereby eliminating considerable noise and confusion and speeding up the transmission of news of the legislators.

THE ENGINEER'S ENGLISH

SEVERAL trade and engineering journals—particularly those that are published by engineering societies—have had considerable to say recently concerning the usage of English by technical men. They lament the inability of the average engineering-school graduate to present his thoughts in clear, understandable, correctly spelled words, and are of the belief that this shortcoming materially impedes his progress in his profession. There can be little doubt that this is true, and the wonder of it all is that engineering colleges have not made the requirements for a degree more strict.

The graduating engineer, when he seeks a job, first has need of a good working knowledge of the English language. He is judged largely by the way he constructs his letter of application, for the presentation which he makes of his qualifications, whether good or bad, often determines what sort of company employs him. Once he is located, he is continually required to write letters and reports. He must also talk with his superiors and with his firm's customers. Words are the only means open to him for conveying his thoughts and expressing his opinions. Even if he is a good engineer, he must convince others of that fact before he can advance very far.

Calculations can be made in a hurry on a slide rule, but there is no short cut in composition. Furthermore, we do not believe that there are "natural-born" writers. The ability to write well is the result of study, observation, and practice, the same as proficiency in anything else. The good writer is the careful writer, and in most instances is the one who rewrites important matter from one to five times before he allows it to go forth as his representative.

In years past we knew a college professor who subtracted five points for every misspelled word in examination papers. He taught the subject of crystallography, which has more than its just share of long words. His students considered him a rather fiendish person; but no doubt they have had reason many times since then to give thanks because he would not countenance lazy or indifferent learning or writing.

A NEW TOURIST MECCA

WHEN the Boulder Canyon Project was in the drawing-board stage, few persons visualized it in other than a utilitarian light. Its proponents listed many benefits that would accrue from it, but all of them could be classified as economic ones. Actually, however, the great dam on the Colorado River and the lake that it has created seem destined to befriend mankind in another important but less tangible way than by creating kilowatts and preventing floods.

We refer to the scenic and recreational aspects of the undertaking. The Bureau of Reclamation, which sired the project, is already urging people to consider Boulder Dam when making up their vacation itineraries and, in line with the modern trend of travel, is planning an auto-trailer camp in the model town of Boulder City.

Lake Mead, with its 550 miles of shore line, has converted a stretch of desert into an oasis. Over the glimmering surface of its crystal-clear waters, motorboats now carry tourists on an enchanting journey past towering cliffs that few human eyes ever gazed upon before the river was harnessed. Waterfalls of great beauty have been discovered only since this new avenue of travel has existed.

The National Park Service, which has been given supervision of the area, will provide accommodations for visitors similar to those found in the various national parks. Already there is an air-conditioned hotel in Boulder City, or one may stop in Las Vegas, Nev., some 25 miles from Boulder Dam. Spring and autumn are the most desirable seasons to visit this world-famous project. Although the lake has tempered the climate to some extent, summer temperatures are ordinarily too high for human comfort.

THE CHEMIST AND THE BAKER

A GENERATION or two ago, when home-baked bread and cakes were the rule, no one ever thought of chemistry in relation to baking, but times have changed. In an effort to make their foodstuffs uniformly good, bakers are paying attention to every detail that enters into the production of bread and pastry, and are retaining chemists to help them solve some of their problems. Apparently, this has been a paying move, for the sale of bread is gradually rising from the alarmingly low level it reached in 1933 in both the United States and Canada. The falling off was attributed in part to the depression, but also to inroads made by cereals in the form of tasty products that were popularized through attractive advertising. Chemists were called in to help restore bread to its former place of importance in the dietary. They proceeded on the assumption that if its taste could be improved sales would increase.

Their investigations disclosed that ineffective cleaning of the baking pans made bread less palatable, for accumulating burnt grease and crumbs from successive bakings gave rise to unsavory odors that were absorbed by the baking loaf. The remedy there was the use of detergents and solvents. Similarly, they found that ink and wax, if employed too liberally on the paper in which the loaves were wrapped, likewise unfavorably affected the flavor of the bread. By changing to plain paper, one bakery increased its bread sales 25 per cent.

The chemists are now also doing something about cakes and pies. They have learned that such a little thing as the amount of water used in making pie crust is vitally important. Doubtless, our grandmothers knew that, too. Other investigations are concerned with the improvement of flavorings, coloring agencies, shortenings, fruits, nuts, and other cake ingredients. For all these things mankind will give ceaseless thanks.

Industrial Notes

Hilary St. Clair, of the U. S. Bureau of Mines, is credited with having developed a method of clearing the atmosphere of smoke by the use of sound waves.

Holland has completed plans for the construction of a tunnel under the River Meuse at Rotterdam, the country's largest port. Tentatively, they call for a single large tube with three lanes for automobile traffic —two for normal use and one reserve—a bicycle path, and a footwalk. The project will involve an expenditure of $7,500,000, and is the first of its kind to be undertaken there.

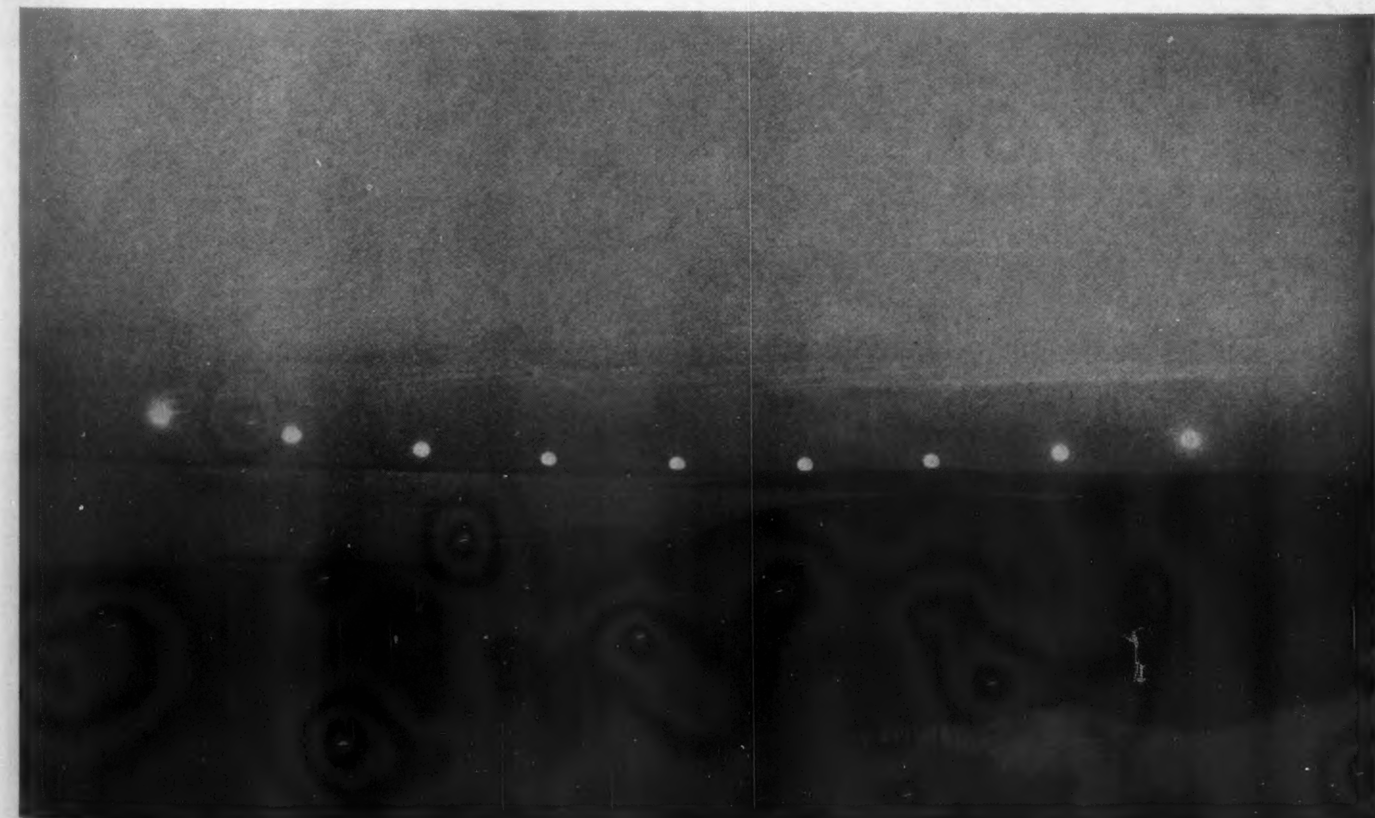
Pumice is finding increasing application in Italy where it is being mixed with asphalt for use in road construction and substituted for sand in making artificial building sheets and blocks. The latter material is characterized by extreme lightness; can be sawed and nailed; is not affected by moisture and changes in temperature; and is said to be twice as resistant to heat and sound as is concrete.

In line with Germany's plan for four years of self-sufficiency in raw materials, the nonferrous-metal industry is substituting phosphor-zinc for phosphor-copper in refining such alloys as brass, tombac, German silver, etc. It is sold under the name of Metallophos in the form of handy blocks containing from 20 to 30 per cent phosphorus, or just twice as much as the commercial phosphor-copper.

Scale-go is the name of a new substance that is said to eliminate pitting and corrosion of and scale formation in boilers and hot-water systems. It is a laboratory product of the Brooks Oil Company, which claims that it neutralizes the harmful minerals in water without impairing the boiler walls and contaminating live steam used in processing products of various kinds. In addition to being a preventive, the material will dissolve existing scale, thus permitting it to pass easily through the blow-off.

The Blank Processed Cements is the title of the first of a series of booklets published by the Cement Process Corporation and dealing briefly with the manufacture and uses of cements made by the patented Blank process. It is divided into two parts: one on Plastocement—masonry cements for bricklaying, plastering, and stuccoing, and the other on special cements for all-purpose concrete construction. The publication contains numerous illustrations of different applications of these materials, and also includes tables giving their chemical analysis, tensile strength, and physical properties. A copy may be obtained upon request from the company's main office, 90 Broad Street, New York, N. Y.

Engineers and others that have to deal with wiring problems will find the *Industrial Guide for the Selection of Wire and Cable* very helpful. It was published principally for them by the Anaconda Wire & Cable Company, and more as a review of types available for specific purposes than as a substitute for personal diagnosis and treatment of individual problems. In its 32 pages are discussed the importance of up-to-date wiring and the factors that must be considered in choosing wire and cable. It contains nine colored charts covering power circuits, standard building wire and cable, portable and flexible cable, flexible cords, and control circuits. These charts are so arranged that, with a knowledge of the service requirements and conditions, it is possible, by following the printed directions in the book, to make the right selection. A copy of the guide may be obtained from the company, 25 Broadway, New York, N. Y.



THE MIDNIGHT SUN

This interesting photograph was taken at Great Bear Lake, North West Territories, Canada, by W. McLanders of Sandon, British Columbia. It is the result of nine exposures of the same film at 20-minute intervals over a period of 2 hours and 40 minutes, during which the position of the camera remained unchanged. The first exposure was made at 10.40 at night, when the sun was at the extreme left, and the last one at 1.20 a. m., when the sun was at the extreme right. The central circle indicates its position at exactly midnight. Great Bear Lake is situated on the Arctic Circle.